AD-A149 730 COOPER RIVER REDIVERSION PROJECT LAKE MOULTRIE AND SANTEE RIVER SOUTH CRR. (U) CORPS OF ENGINEERS CHARLESTON SC CHARLESTON DISTRICT AUG 76 1/2

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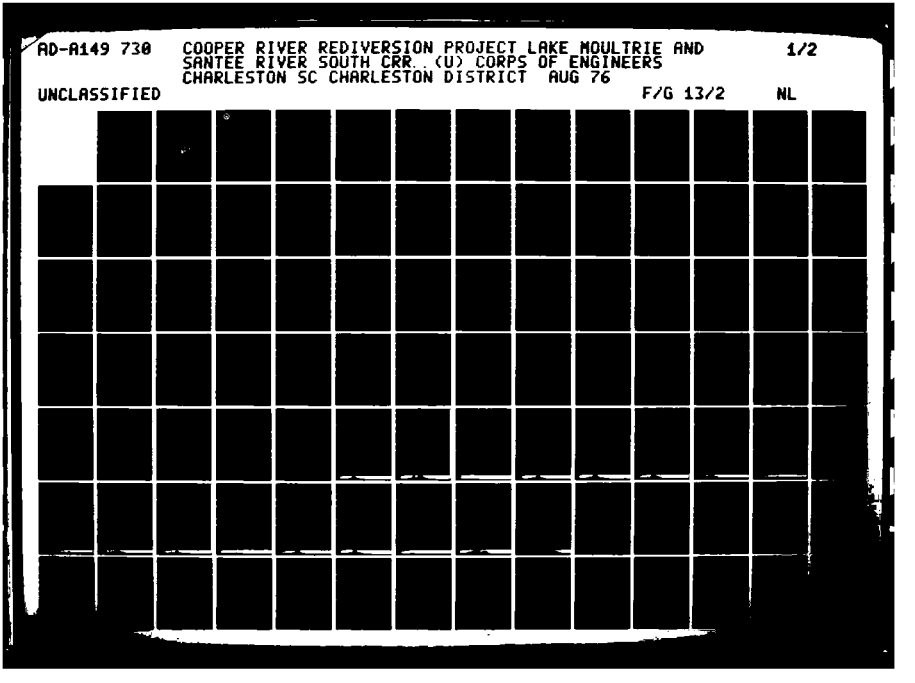
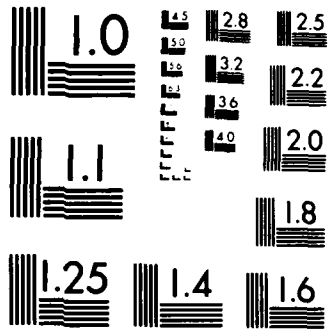




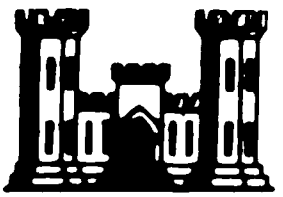
DESIGN MEMORANDUM NO. 8

COOPER RIVER REDIVERSION PROJECT

LAKE MOULTRIE AND SANTEE RIVER

SOUTH CAROLINA

RELOCATION OF SEABOARD COAST LINE RAILROAD BRIDGE



U.S. ARMY ENGINEER DISTRICT, CHARLESTON
CORPS OF ENGINEERS
Charleston, South Carolina

PREPARED BY
RALPH WHITEHEAD & ASSOCIATES
CONSULTING ENGINEERS
CHARLOTTE, N.C.

Aug, 1976

COPY NO. 58

DEPARTMENT OF THE ARMY
OFFICE OF THE CHIEF OF ENGINEERS
WASHINGTON, D.C. 20314

REPLY TO
ATTENTION OF:

DAEN-CWE-BB

26 January 1977

SUBJECT: Cooper River Rediversion Project, Lake Moultrie and Santee River, South Carolina, Design Memorandum No. 8, Relocation of Seaboard Coast Line Railroad Bridge

Division Engineer, South Atlantic
ATTN: SADEN-GK

1. Reference 1st Indorsement SADEN-GK, 16 December 1976 on letter SACEN-GS, 30 August 1976, subject as above.

2. The comment in the following paragraph on the subject design memorandum is furnished for appropriate action.

3. The Attorney's Justification Report states that the railroad owns a fee simple determinable title, subject to defeasance if not used for the operation of a railroad. The present design memorandum contemplates a relocation in place with no realignment. In the event a realignment should be made and the present alignment abandoned, the reverter would take effect. In such case it appears that a condemnation proceeding would be necessary in order to extinguish the reverter interest.

FOR THE CHIEF OF ENGINEERS:

HOMER B. WILLIS
Chief, Engineering Division
Directorate of Civil Works

SADEN-GK (26 Jan 77) 1st Ind
SUBJECT: Cooper River Rediversion Project, Lake Moultrie and Santee River, South Carolina, Design Memorandum No. 8, Relocation of Seaboard Coast Line Railroad Bridge

DA, South Atlantic Division, Corps of Engineers, 510 Title Building, 30 Pryor Street, S. W., Atlanta, Georgia 30303 15 February 1977

TO: District Engineer, Charleston, ATTN: SACEN-GS

Referred for appropriate action.

FOR THE DIVISION ENGINEER:

for WILLIAM N. McCORMICK, JR.
Chief, Engineering Division

SACEN-G (26 Jan 77) 2nd Ind
SUBJECT: Cooper River Rediversion Project, Lake Moultrie and Santee River, South Carolina, Design Memorandum No. 8, Relocation of Seaboard Coast Line Railroad Bridge

DA, Charleston District, Corps of Engineers, 334 Meeting Street, Charleston, SC, 29402, 28 February 1977

TO: Division Engineer, South Atlantic, ATTN: SADEN-GK

1. This office concurs with the principal of law stated in paragraph 3 of basic letter.

2. The Attorney's Justification Report is consistent with the presently approved plan of relocating the railroad in place. However, the Report will be amended to state that the reverter must be extinguished if present plans are changed to call for the abandonment of any railroad right-of-way.

HARRY S. WILSON, JR.
Colonel, Corps of Engineers
District Engineer

SADEN-GK (26 Jan 77) 3rd Ind
SUBJECT: Cooper River Rediversion Project, Lake Moultrie and Santee River, South Carolina, Design Memorandum No. 8, Relocation of Seaboard Coast Line Railroad Bridge

DA, South Atlantic Division, Corps of Engineers, 510 Title Building, 30 Pryor Street, S. W., Atlanta, Georgia 30303 15 March 1977

TO: District Engineer, Charleston, ATTN: SACEN-G

Information furnished is satisfactory.

FOR THE DIVISION ENGINEER:

WILLIAM N. McCORMICK, JR.
Chief, Engineering Division

Copy Furnished:
HQDA (DAEN-CWE-BB)
w/cy all Inds

SADEN-GK (30 Aug 76) 3rd Ind
SUBJECT: Cooper River Rediversion Project, Lake Moultrie and Santee River, South Carolina, Design Memorandum No. 8, Relocation of Seaboard Coast Line Railroad Bridge

DA, South Atlantic Division, Corps of Engineers, 510 Title Building, 30 Pryor Street, S. W., Atlanta, Georgia 30303 15 February 1977

TO: District Engineer, Charleston, ATTN: SACEN-GS

Information furnished in the 2nd Indorsement is satisfactory subject to the following comment:

Paragraph 3. The sentence "The material is expected to average a blow count of about 30 and should adequately support the track loads" is not clear. The adequacy of the embankment to support the loads should be based on strength tests.

FOR THE DIVISION ENGINEER:

Incl wd

WILLIAM N. McCORMICK, JR.
Chief, Engineering Division

Copy Furnished:
HQDA (DAEN-CWE-B)
w/10 cys Incl 1

SACEN-GS (30 Aug 76) 4th Ind
SUBJECT: Cooper River Rediversion Project, Lake Moultrie and Santee River, South Carolina, Design Memorandum No. 8, Relocation of Seaboard Coast Line Railroad Bridge

DA, Charleston District, Corps of Engineers, P. O. Box 919, Charleston, South Carolina 29402 19 April 1977

TO: Division Engineer, South Atlantic, Attn: SADEN-GK

1. The following comments are in response to the 3rd Indorsement:

a. A ballast thickness design was performed in accordance with an article in AREA Bulletin 641, Proceedings Volume 74, entitled "Railroad Subgrade Stresses." Using this procedure, a ballast thickness curve was constructed for safety factors of 1.5 and 2.0. A copy of the curve plot is inclosed. The selected design subgrade strength (C = 950 lb/sq ft) was an average of the Q and R strengths from controlled strain triaxial tests performed on remolded composite sample C-1 from Borings BA-1 and BA-2 in the proposed borrow area (see Plate 7 in DM No. 8 for location). Strength test reports are presented in Appendix D in DM No. 8.

b. Based on the above design procedure, it is recommended that the following ballast sections be used for final design:

(1) Permanent Track - 18" under the ties (8" top ballast and 10" sub-ballast), Factor of Safety = 2.0, 8" top ballast matches ballast section on the bridge.

(2) Detour Track - 14" under the ties, (6" top ballast and 8" sub-ballast), Factor of Safety = 1.7.

2. The recommended sections do not reach the "rule of thumb" depth of 21" (center to center of tie spacing), but are somewhat greater than present SCL Railroad standards.

FOR THE DISTRICT ENGINEER:

1 Incl (4 cys)
as

JACK G. LESEMANN
Chief, Engineering Division

SADEN-GK (30 Aug 76) 5th Ind
SUBJECT: Cooper River Rediversion Project, Lake Moultrie and Santee River, South Carolina, Design Memorandum No. 8, Relocation of Seaboard Coast Line Railroad Bridge

DA, South Atlantic Division, Corps of Engineers, 510 Title Building, 30 Pryor Street, S. W., Atlanta, Georgia 30303 2 May 1977

TO: District Engineer, Charleston, ATTN: SACEN-GS

Information furnished in subject Indorsement is satisfactory.

FOR THE DIVISION ENGINEER:

Incl wd

for WILLIAM N. McCORMICK, JR.
Chief, Engineering Division

Copy Furnished:
HQDA (DAEN-CWE-BB)
w/3 cys 4th Ind

SACEN-GS (30 Aug 76) 6th Ind
SUBJECT: Cooper River Rediversion Project, Lake Moultrie and Santee River, South Carolina, Design Memorandum No. 8, Relocation of Seaboard Coast Line Railroad Bridge

DA, Charleston District, Corps of Engineers, P. O. Box 919, Charleston, South Carolina 29402 11 July 1977

TO: Division Engineer, South Atlantic, Attn: SADEN-GK

1. It is proposed that a walkway be added to the east side of the railroad bridge. A typical section is shown on the inclosed sketch. As standard procedure, the SCL Railroad has instigated the practice of constructing walkways on at least one side of all new structures and on all deck replacements of existing structures. The refuge bays currently included on the bridge would be deleted if the walkway is added.

2. The obvious advantage of the walkway would be the increased safety for personnel crossing the bridge. Railroad personnel would benefit from the walkway in performing their bridge and train inspections and other routine duties involving the bridge. Government personnel could more safely perform inspection and maintenance of the canal and integrated substructure without concern or knowledge of train schedules. Equally important, the walkway would allow safe passage for a considerable number of people that will be attracted to the bridge vicinity because of the increased hunting and fishing opportunities enhanced solely as a result of the Government project.

3. For the foregoing reasons, and particularly considering that the walkway would be a valuable public safety feature on a structure located across and made necessary by a Government project, it is proposed to build the walkway as a part of the replacement facilities that will be provided by the Government to the SCL Railroad. The estimated increase in contstruction cost of the railroad relocation due to the walkway addition is $30,000.

FOR THE DISTRICT ENGINEER:

for JACK J. LESEMANN
Chief, Engineering Division

1 Incl
as

SADEN-GK (30 Aug 76) 7th Ind
SUBJECT: Cooper River Rediversion Project, Lake Moultrie and Santee River, South Carolina, Design Memorandum No. 8, Relocation of Seaboard Coast Line Railroad Bridge

DA, South Atlantic Division, Corps of Engineers, 510 Title Building, 30 Pryor Street, S. W., Atlanta, Georgia 30303 19 July 1977

TO: District Engineer, Charleston, ATTN: SACEN-GS

Addition of the walkway to the SCL railroad bridge is approved. This is in accordance with the guidance established by DAEN-CWE-B (SAMEN-P, 12 Jun 70) 12th Indorsement on Gainesville Design Memorandum No. 9, dated 29 March 1972 (Inclosure 5).

FOR THE DIVISION ENGINEER:

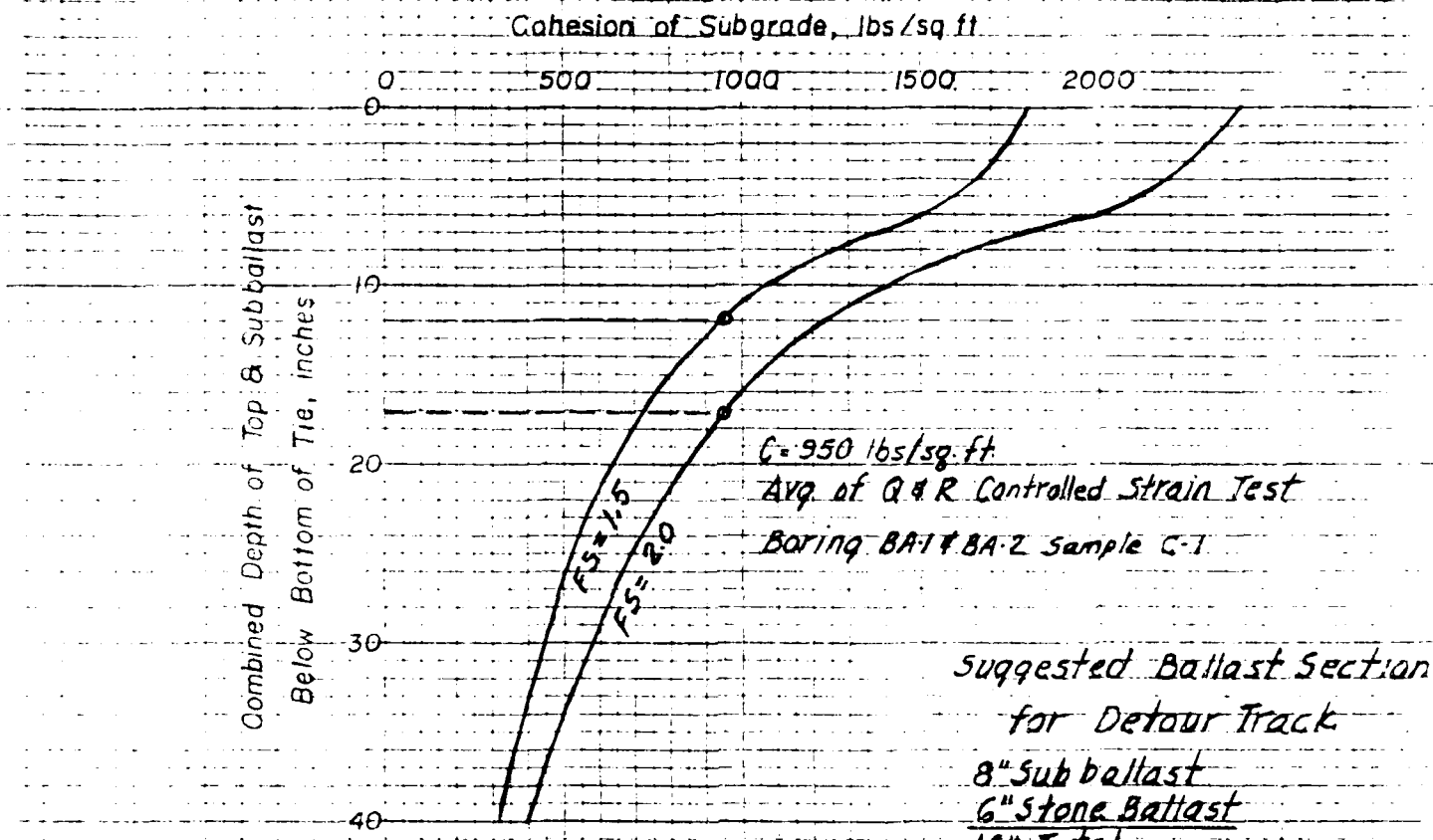
WILLIAM N. McCORMICK, JR.
Chief, Engineering Division

1 Incl
wd Incl 4
added Incl 5
5. as

Copy Furnished:
HQDA (DAEN-CWE-BB)
w/cy Incl 4 & 5

APR 77

SCL RAILROAD BRIDGE
COOPER RIVER REDIVERSION PROJECT

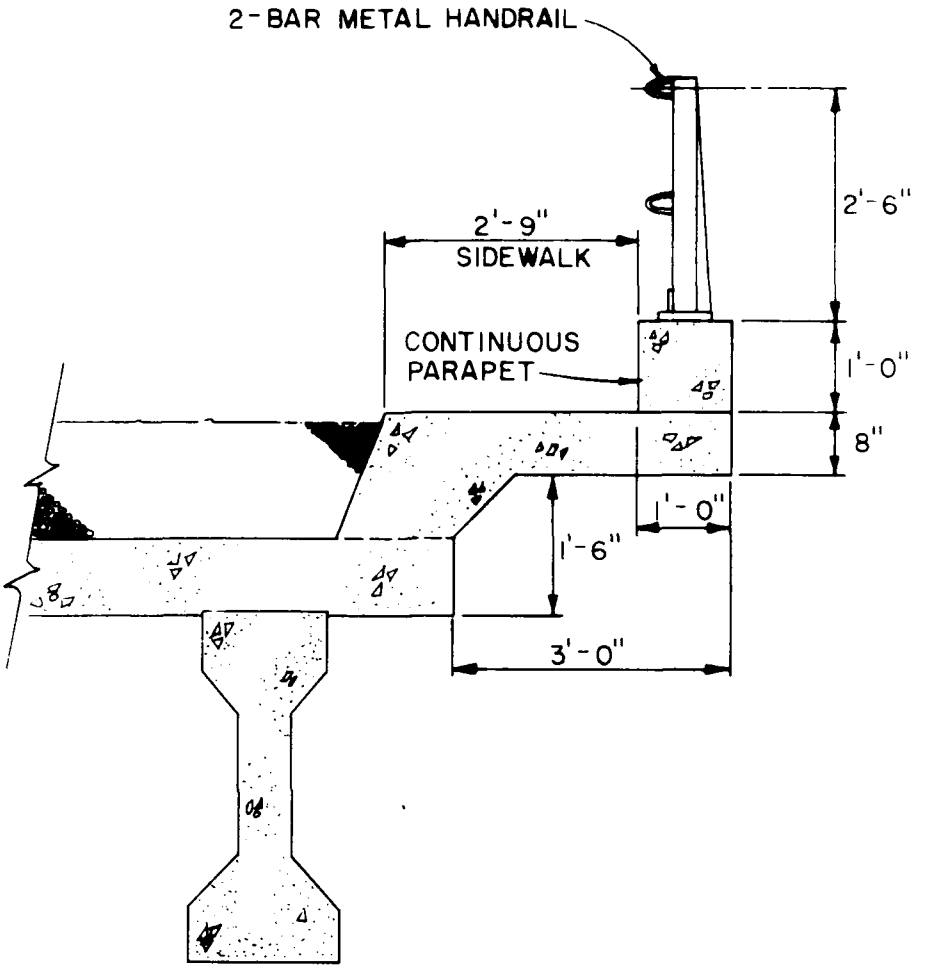


Suggested Ballast Section
for Detour Track
8" Sub ballast
6" Stone Ballast
14" Total

Note: Curves Constructed Assuming Vertical Pressure at Base of Tie of 6k/sq ft

Suggested Ballast Section
for Permanent Track back
of Abutments
10" Sub ballast
8" Stone Ballast
18" Total

Incl 1



WALKWAY SECTION

SCALE: 1/2" = 1'-0"

EAST SIDE ONLY

COOPER RIVER REDIVERSION PROJECT DM #8

RELOCATION OF

SEABOARD COASTLINE RAILROAD BRIDGE

WALKWAY ON BRIDGE

7 JULY 1977

DAEN-CWE-B (SAMEN-P, 12 Jun 70) 12th Ind
SUBJECT: Gainesville Lock and Dam, Tennessee-Tombigbee Waterway, Alabama and Mississippi - Design Memorandum No. 9, Relocation, Adjustment A.T. & N. (Frisco) Railway Crossing of Tombigbee River Between Cochrane and Alicaville, Alabama

DA, Office of the Chief of Engineers, Washington, D.C. 20314 29 March 1972

TO: Division Engineer, South Atlantic, ATTN: SADEW

1. The actions indicated and the information furnished in the 10th Indorsement and Inclosures No. 3, No. 4 and No. 5 thereto are satisfactory, subject to the comments of the Division Engineer in the 11th Indorsement and to the following comment.

2. 11th Indorsement, Paragraph 1. Due to the apparent safety hazards associated with this bridge, such as height, length, poor sight distance and maintenance problems, a walkway appears justified and should not be considered a betterment. Similar walkways have been provided in bridge structures for this railroad over the Arkansas River and other locations.

3. 11th Indorsement, Paragraph 3. Exception is taken to the statement in the 3rd sentence: "Since current Corps policy does not permit consideration of the overall facility,...." The current policy in the Corps does permit consideration, on an individual basis, of the overall facility. However, the conclusion of the Division Engineer, i.e., that the entire cost of the improved design of the new bridge be paid for by the railroad, is appropriate in the instant case.

FOR THE CHIEF OF ENGINEERS:

wd all incl

JOSEPH M. CALDWELL
Chief, Engineering Division
Directorate of Civil Works

DEPARTMENT OF THE ARMY
CHARLESTON DISTRICT, CORPS OF ENGINEERS
P O BOX 919
CHARLESTON, S.C. 29402

SACEN-GS

30 August 1976

SUBJECT: Cooper River Rediversion Project, Lake Moultrie and Santee River, South Carolina, Design Memorandum No. 8, Relocation of Seaboard Coast Line Railroad Bridge

Division Engineer, South Atlantic
ATTN: SADEN-GK

1. Transmitted are 13 copies of the subject design memorandum, submitted for approval in accordance with applicable provisions of ER 1110-2-1150 and SAD Supplement 1 to the regulation. The design memorandum was prepared by Ralph Whitehead and Associates, Consulting Engineers, for the Charleston District.

2. It is recommended that this design memorandum be approved as a basis for negotiating a relocation contract with the SCL Railroad and for preparation of construction plans and specifications. It is noted that according to the terms of the contract for services for design of the SCL Railroad Bridge, the Government has 180 days after completion of the design memorandum in which to exercise its option to notify the A-E to proceed with preparation of the plans and specifications.

Harry S. Wilson, Jr.

1 Incl (13 copies)
fwd sep

HARRY S. WILSON, JR.
Colonel, Corps of Engineers
District Engineer

GUARDIAN OF FREEDOM BICENTENNIAL 1775-1975 UNITED STATES ARMY

AMERICAN REVOLUTION BICENTENNIAL 1776-1976

SADEN-GK (30 Aug 76) 1st Ind 16 December 1976
SUBJECT: Cooper River Rediversion Project, Lake Moultrie and Santee River, South Carolina, Design Memorandum No. 8, Relocation of Seaboard Coast Line Railroad Bridge

(2) Sheet Nos. 9 thru 13. The condition with initial prestress force (without losses) and dead load of girder is not shown in these computations. This condition should be investigated since it appears that allowable tensile stress for the concrete will be exceeded for this condition.

2. The date you expect to submit the necessary response should reach SADEN-GK by 3 January 1977.

FOR THE DIVISION ENGINEER:

B. L. Kittle

Incl wd

for WILLIAM N. McCORMICK, JR.
Chief, Engineering Division

Copy furnished:
HQDA (DAEN-CWE-B)
w/10 cys Incl 1

SACEN-GS (30 Aug 76) 2nd Ind
SUBJECT: Cooper River Rediversion Project, Lake Moultrie and Santee River, South Carolina, Design Memorandum No. 8, Relocation of Seaboard Coast Line Railroad Bridge

DA, Charleston District, Corps of Engineers, P. O. Box 919, Charleston, South Carolina 29402 28 January 1977

TO: Division Engineer, South Atlantic, Attn: SADEN-GK

The following comments are in response to paragraphs in SADEN-GK, 1st Indorsement dated 16 December 1976, subject as above.

1. Paragraph 1a. Concur.

2. Paragraph 1b. Concur. Paragraph 25 has been expanded. Remove main text page 12 and insert revised pages 12 and 12a, inclosed.

3. Paragraph 1c. The ballast section indicated for the detour track and the rebuilt main track behind each new abutment is the current SCL Railroad standard. The SCL Railroad has advised that they recognize that their current standard section does not provide an adequate depth of ballast and sub-ballast and they are in the process of revising their standard. The final plans will provide a depth of ballast and sub-ballast consistent with the new standard to be adopted by the SCL Railroad. Only about 20 feet of the main track behind each new abutment will be disturbed during construction and will require complete rebuilding of the ballast section. The remaining work on the main track consists only of grade adjustment which should not require roadbed design. The short sections of roadbed embankment will be constructed with material from the borrow pit compacted at optimum water content for maximum density. The material is expected to average a blow count of about 30 and should adequately support the track loads. Boring logs for the borrow area and results of laboratory compaction tests and strength tests are shown in Appendix No. "D". Roadbed design will be coordinated with the Railroad during preparation of plans and specifications.

4. Paragraph 1d. Consideration was given to excavating beneath the bridge prior to construction of the piers. Since the existing ground and water table are at approximately Elevation 21.0 and the bottom of the canal pier footings is at approximately Elevation -5.0, pier construction would be

inside cofferdams to permit open construction. The cofferdams can best be constructed and dewatered with earth surrounding the cofferdams. This also provides an adjacent work area. The pier footings are founded on hard material (dense silty sand with a high blow count) so that no damage as a result of heave or lateral movement is anticipated. The 50-foot length of canal excavation discussed in paragraph 34 would be accomplished near the end of bridge construction and would consist of removing soil from around the cofferdams.

5. Paragraph 1e. It was assumed that this matter could be handled under the standard paragraph entitled, "Disposal of Excavated Material" (ECI 16-401.2(a)(5)) which is a part of our SF 20, Invitation for Bids (Construction Contract). This paragraph provides for a listing of owners in the vicinity of the work who are known to desire fill material. The technical provisions of the specifications then give the procedure to follow if the contractor desires to use an alternate disposal area and states that if, after the award of the contract, a disposal area other than that stipulated in these specifications is proposed, its acceptance will be subject to the approval of the Contracting Officer after an adjustment of the contract price, if found necessary by the Contracting Officer to protect the Government interest.

6. Paragraph 1f. Concur.

7. Paragraph 1g(1). The practice of the SCL Railroad is to use A-588 steel with allowable stresses as specified for A-36 steel. Comparative cost estimates were prepared on this basis. If allowable stresses as specified in AREA for A-588 steel were used, the structural steel quantity for Scheme 4 (steel girder with composite slab) shown in Appendix "C", page 2, could be reduced by about 13 percent. This would reduce the overall cost of Scheme 4 by only about 4 percent. The recommended Scheme 5 (prestressed concrete girders with composite deck) would remain more economical than Scheme 4.

8. Paragraph 1g(2). Sheets 11 through 13 have been revised and expanded to show the condition with initial prestress force. The design, in accordance with AREA Specifications, indicates that four Type IV girders with 32 strands are adequate for the span length and loads selected. Remove pages 11 through 13 of Appendix "B" and insert revised pages inclosed.

FOR THE DISTRICT ENGINEER:

1 Incl (13 cys)
as

JACK J. LESEMANN
Chief, Engineering Division

SADEN-GK (30 Aug 76) 1st Ind
SUBJECT: Cooper River Rediversion Project, Lake Moultrie and Santee River, South Carolina, Design Memorandum No. 8, Relocation of Seaboard Coast Line Railroad Bridge

DA, South Atlantic Division, Corps of Engineers, 510 Title Building, 30 Pryor Street, S. W., Atlanta, Georgia 30303 16 December 1976

TO: District Engineer, Charleston ATTN: SACEN-GS

1. Design Memorandum No. 8 is approved subject to the following comments:

a. Page 6, para. 12d. The responsibility for performing the trackwork must be agreed on prior to final plans and specifications submittal.

b. Page 12, para. 25. This paragraph should be expanded to briefly discuss methods to be utilized at the construction site to control sedimentation.

c. Page 15, para.32. Recent experience has shown that 10 inches of ballast and sub-ballast is not sufficient for main line tracks. The 1973 AREA Manual indicates a minimum of 12 inches of ballast and 6 inches of sub-ballast should be provided. Hay and Talbot recommend that normal ballast thickness should be approximately equal to the tie spacing. The ballast thickness should be re-evaluated. Design of the roadbed, including types of material, strengths of subgrade, bearing capacity, etc. should be furnished. This should be coordinated with the Railroad for their standards.

d. Page 16, para. 34. Consideration should be given to excavating beneath the bridge prior to constructing the piers to eliminate the possibility of damage to the piers as a result of heave or lateral movements.

e. The information contained in Exhibit 4 concerning the disposition of surplus fill material is incorrect. The transfer of ownership of the fill material must remain within the prerogative of the Government and, in most instances, compensation is required.

f. Although not mentioned, it is noted that the detour track and the borrow area are located outside of the canal right-of-way. It should be understood that the acquisition of these temporary rights will be the responsibility of the Government.

g. Appendix "B".

(1) Sheet No. 5. The use of allowable stresses based on ASTM A-36 steel (FY = 36 ksi) when ASTM A-588 steel (Fy = 50 ksi) is specified should be justified and comparative cost estimates revised accordingly.

This Design Memorandum on Relocation of Seaboard Coast Line Railroad Bridge is submitted in accordance with applicable provisions of ER 1110-2-1150. It is the eighth of a series covering project studies for the Cooper River Rediversion Project.

Title	Date Submitted	Design Memorandum No.
General Design Memorandum	Jan 72	1
General Design Memorandum, Supplement No. 1, Comparison of Alternative Plans	Oct 73	1
Turbines, Governors, and Generators	Jun 73	2
Entrance Channel In Lake Moultrie	Mar 74	3
Access Roads and Construction Facilities	May 74	4
Real Estate, Area 1	Sep 74	5
Site Selection and Geology	May 75	6
Preliminary Design Report - Powerplant	Jan 76	7
Relocation of Seaboard Coast Line Railroad Bridge	Aug 76	8
Canals - Intake and Tailrace	June 76	9

COOPER RIVER REDIVERSION PROJECT

LAKE MOULTRIE AND SANTEE RIVER, SOUTH CAROLINA

SCHEDULE FOR SUBMISSION OF FUTURE DESIGN MEMORANDUM

Title	Scheduled Submittal Date
Real Estate, Area 2	Nov 76
Construction Materials	Apr 77
Feature Design - Powerplant	Apr 77
Fish Hatchery	Jun 77
Cooling Water System	Jul 77
Relocations - Utilities	Jul 77
Relocations - Roads	Jul 77
Water Quality Monitoring Equipment	Nov 77
Instrumentation	Mar 81

COOPER RIVER REDIVERSION PROJECT

LAKE MOULTRIE AND SANTEE RIVER, SOUTH CAROLINA

DESIGN MEMORANDUM NO. 8

RELOCATION OF
SEABOARD COAST LINE RAILROAD BRIDGE

CONTENTS

TEXT

CONTENTS Contd.

TEXT Contd.

EXHIBITS

PLATES

APPENDIX

COOPER RIVER REDIVERSION PROJECT

LAKE MOULTRIE AND SANTEE RIVER, SOUTH CAROLINA

DESIGN MEMORANDUM NO. 8

RELOCATION OF
SEABOARD COAST LINE
RAILROAD BRIDGE

PERTINENT DATA

DRAINAGE AREA	Square miles
Lake Moultrie	15,000
Lake Marion	14,700
RESERVOIR AREAS	Acre-feet
Maximum power pool	
Lake Moultrie	1,110,000
Lake Marion	1,450,000
Minimum power pool	
Lake Moultrie	450,000
Lake Marion	350,000
ELEVATIONS	Feet, msl
Top of dam	
Lake Moultrie	88.0
Lake Marion	88.0
Maximum water surface	
Lake Moultrie	75.2
Lake Marion	76.8
Top of gates	
Lake Moultrie	--
Lake Marion	76.8
Spillway crest	
Lake Moultrie	--
Lake Marion	63.0
Maximum power pool	
Lake Moultrie	75.2
Lake Marion	76.8
Minimum power pool	
Lake Moultrie	60.0
Lake Marion	60.0
Normal tailwater	
Lake Moultrie	7.2
Lake Marion	27.0

PERTINENT DATA (Cont'd)

Minimum tailwater		
Lake Moultrie	-1.5	
Lake Marion	26.0	
WILSON DAM (Forms Lake Marion)		
Completion date	23 March 1942	
Length - miles	7.8	
Height of spillway - feet	48	
Spillway		
Design capacity - cfs	800,000	
Length - feet	3,400	
Gates		
Number	62	
Size - feet	14 x 50	
REDIVERSION PROJECT		
Canal length - miles	11.5	
Intake canal invert elevation - msl	50.0	
Tailrace canal invert elevation - msl	0.0	
Maximum tailwater elevation - msl	23.4	
Maximum discharge - cfs	24,500	
Maximum canal velocities - fps	3	
Canal bottom width - feet	285	
POWERHOUSE		
Generators	3	
Capacity each	28,000	kw
Rating	29,474	kva
Turbines		
Type	Fixed blade	
Rating @ 49 ft. head	39,000	hp

COOPER RIVER REDIVERSION PROJECT

LAKE MOULTRIE AND SANTEE RIVER, SOUTH CAROLINA

DETAIL DESIGN MEMORANDUM

RELOCATION OF
SEABOARD COAST LINE RAILROAD BRIDGE

PREPARED BY

RALPH WHITEHEAD AND ASSOCIATES
CONSULTING ENGINEERS
CHARLOTTE, NORTH CAROLINA

FOR

DEPARTMENT OF THE ARMY
CHARLESTON DISTRICT, CORPS OF ENGINEERS
CHARLESTON, SOUTH CAROLINA

AUGUST 1976

INTRODUCTION

1. Authorization. The facility covered in this report comprises part of the Cooper River Rediversion Canal Project, Lake Moultrie and Santee River, South Carolina. The Cooper River Rediversion Project, which will reduce shoaling and restore the historic saline regimen to Cooper River and Charleston Harbor, was authorized by the River and Harbor Act of 1968 (P.L. 90-483, 90th Congress, S. 3710, August 13, 1968). Section 101 of the 1968 Act is quoted in part as follows:

> "....That the following works of improvement of rivers and harbors and other waterways for navigation, flood control, and other purposes are hereby adopted and authorized to be prosecuted under the direction of the Secretary of the Army and supervision of the Chief of Engineers, in accordance with the plans and subject to the conditions recommended by the Chief of Engineers in the respective reports hereinafter designated....Cooper River,

Charleston Harbor, South Carolina: Senate Document Numbered 88, Ninetieth Congress, at an estimated cost of $35,381,000...."

2. Purpose. This memorandum presents information describing the effects of the project on the Seaboard Coast Line Railroad Facilities and a proposed relocation plan, including costs, justification and design criteria, which would provide appropriate and reasonable compensation to the railroad. This report is submitted for approval of the relocation plan to serve as a basis for subsequent contract negotiations, detailed plans and specifications, and ultimate construction.

3. Scope. This memorandum provides a detailed study and proposed solution for the problem created where the proposed tailrace canal severs the Seaboard Coast Line Railroad track at Mile Post A-347.96 (centerline canal approximately 211.2 feet north of MP A-348). The following items are included:

a. Report of Necessity.

b. Criteria for Design and Specifications for use in preparing construction plans and specifications for the work recommended in this DDM.

c. Discussion of the various features pertinent to the design and selection of the proposed bridge structure.

d. Discussion of the various features pertinent to the location and design of the temporary detour track.

e. Cost analysis and detailed drawings of scheme selected.

f. Recommendation of the one most desirable solution.

g. Legal Obligations - The legal obligations of the United States Government are discussed in the Attorney's Report, Appendix "A".

4. Location. The proposed structure would be constructed on the existing Seaboard Coast Line Railroad across the tailrace canal of the Cooper River Rediversion Project north of St. Stephen, South Carolina. The railroad bridge would intersect the canal centerline approximately 211.2 feet north of Mile Post A-348 (intersection of

centerline of canal and centerline of railroad at coordinates N. 581,796.07; E. 2,331,170.53; MP A-347.96). Proposed permanent construction (railroad bridge over canal) is within the existing Seaboard Coast Line Railroad right-of-way. The temporary detour track would be, in part, outside of the railroad right-of-way on the west side (upstream side) of the existing track.

5. Owner's Opinion. The development of the relocation plan and arrangements for design and construction have been coordinated with SCL Railroad officials. The Railroad has been afforded the opportunity to review and comment on appropriate aspects of this memorandum which are pertinent to their interests in the plan of relocation. As a result of this coordination, the final relocation plan as presented herein is essentially acceptable by railroad officials and no particular difficulty is anticipated in negotiating a corresponding relocation agreement. Copies of recent pertinent correspondence with the Railroad are shown in Exhibits 1 through 4.

6. Railroad Bridge. The Cooper River Rediversion Project requires the construction of a single-track railroad bridge at MP A-347.96 to provide the required tailrace canal waterway opening through the existing single-track railroad embankment and the area occupied by the existing 282.0 foot long railroad bridge designated as Bridge Section No. 8 of Seaboard Coast Line Bridge over Santee River (bridge located at MP A-347.9). The location of the proposed bridge is shown on Plate 2.

7. Abandonment of Facility. Abandonment of the railroad facility is not feasible for the following reasons:

a. This is the main North-South line (Virginia to Florida) of the Railroad Company. At this location the scheduled daily traffic volume is 15 trains, of which 11 are freight trains and 4 are passenger trains. Additional trains are also required to meet seasonal and other needs.

b. The retention of this railroad line during and after construction of the canal is necessary as there is no reasonable substitute route for this traffic.

DESCRIPTION OF FACILITIES AFFECTED

8. Railroad. The Seaboard Coast Line Railroad main track affected is track supported on earth embankment and on Bridge Section No. 8 of Santee River Bridge. The existing earth embankment is approximately 22 feet high and 25 feet wide at the top with 1.5H to 1.0V side slopes. The track is 132# or 131# continuous welded rail with timber ties and stone ballast on the embankment portion. Existing Bridge Section No. 8 is a 282' long steel girder viaduct consisting of seven riveted girder spans (6 spans @ 41'-6" and one span @ 33'-0") with timber deck, two concrete end abutments, one concrete pier and five steel bents on concrete pedestals. The rails, timber bridge and track ties, stone ballast, earth embankment, and steel and concrete bridge are in good condition as would be required for a main track railroad.

9. Utilities. Utilities affected by the proposed work consist of the Seaboard Coast Line Railroad Communication line (17 wires) paralleling the track on the west side. The lines are supported on timber poles located approximately 42 feet from the centerline of track. The communication lines are within the existing Seaboard Coast Line Railroad right-of-way and would be relocated by the Railroad Company as required for construction.

10. Buried Cables. Signal cables buried in the embankment in the area of the turnout, signals and signal bungalow south of the proposed detour track would not be affected by the proposed construction.

DESIGN, CONSTRUCTION, SUPERVISION AND OWNERSHIP OF NEW FACILITIES

11. Design, Construction and Supervision. The Seaboard Coast Line Railroad has indicated that their design and construction capability for this bridge is limited and they have requested that the Corps of Engineers perform the design and construction of the facility. The Charleston District, Corps of Engineers, would design and advertise the work for competitive bidding with the exception of the items listed below. The detour track and bridge would be constructed under a Government construction contract, supervised and administered by the Charleston District.

12. Work by Railroad. The following items of work would be performed by the Railroad:

a. Work related to signal system and communication system changes and relocation.

b. All trackwork necessary to cut and line existing main track or detour track at each end of detour track and connect to constructed segment of detour track or to existing main track. All track work necessary to maintain detour track above sub-ballast during the time it is in operation.

c. Furnish all material and labor required to cut welded rail and for field welding of the rail.

d. At its option, furnish material, labor and equipment to perform the trackwork (detour track and permanent track) for the project. At its option, the railroad may specify that the Government's Contractor perform the trackwork except as specified in b and c.

e. Furnish supervision and watchmen and flagmen service as required to permit construction of bridge, detour embankment, and any trackwork by the contractor.

13. Work by Government's Contractor. All items of work not performed by the Railroad would be performed by the Government's Contractor.

14. Contract. The Government would negotiate a formal relocation type contract with the Owner, the Seaboard Coast Line Railroad Company. The contract would provide for:

a. Furnishing of labor, materials, and equipment by the Railroad Company to perform the items of work listed above.

b. Alteration of the existing railroad facilities by Government's Contractor and by the Railroad at Government cost to eliminate the interference with the construction, development and use of the project (tailrace canal for Cooper River Rediversion Project).

c. Grant to the Government a right-of-entry to the Owner's right-of-way required for construction of the canal and adjustment of rail facilities.

d. Conveyance, without cost to the Government, by the Railroad of the necessary right-of-way easement for the Government to operate and maintain the tailrace canal as an integral part of the project.

e. Subordination of such Owner's rights to the rights of the Government as are necessary to construct, operate and/or maintain the project for its stated purpose. Subordination rights from the Owner would be obtained in exchange for the relocation work on the Owner's facilities.

15. Ownership of New Facility. The facility constructed for the railroad (bridge over canal) would be the property of the Railroad Company.

PROPOSED PLAN

16. Bridge Structure. A permanent bridge structure would be required to span the proposed tailrace canal. There are no plans for commercial waterborne traffic to utilize the canal in this area. The existing track profile permits a bridge with optimum depth and span lengths and at the same time provides adequate vertical and horizontal clearances for small boats. The spans over the waterway portion of the canal would provide 15.8 feet vertical clearance above Elevation 23.0 (Maximum Normal Tailwater Elevation) and 59 feet minimum horizontal clearance between piers.

17. Track Profile. The existing track profile is approximately level across Santee River and across existing Bridge Section No. 8 and on an ascending grade of approximately 0.45% from Bridge Section No. 8 southward toward St. Stephen. The track profile would be adjusted only as required to provide a satisfactory grade across the proposed structure with satisfactory vertical curves to tie into the existing track profile. The profiles are shown on Plate 3.

18. Construction Schedule. Construction of the detour track, proposed bridge, and main track would be scheduled so as to maintain railroad traffic at all times.

19. Design Criteria and Specifications. Design of the facility would be in accordance with the requirements of the American Railway Engineering Association (AREA) and the standard practices of the Seaboard Coast Line Railroad Company. The design criteria would be as follows:

Design Loading for Bridge	Cooper E 72
Impact: As per AREA Specs.	$I = 35 - \frac{L^2}{500}$ for concrete girders
Design Speed-Detour Track	40 MPH
Maximum Horizontal Curve-Detour Track	2° - 00' (1-1/2" S.E.)
Length of Spirals-Detour Track	160 Feet

Maximum Grade	0.45%
Type of Rail - Main Track	132# & 131# CWR
Type of Rail - Detour Track	132# Jointed Rail

20. Factors Considered - Railroad Bridge. Factors considered and type structure selected for permanent railroad bridge over tailrace canal are as follows:

a. Full compliance with AREA and SCLRR requirements for bridge work.

b. Foundation conditions and height of structure indicate that conventional reinforced concrete piers with spread footings on hard material is the practical and most economical type of sub-structure for the canal portion of the bridge. Comparative cost estimates (see Appendix "C") indicate that the most economical canal span length (balance between sub-structure cost and superstructure cost) is approximately 63 feet in Scheme 4. For the span length selected, comparative cost estimates also indicate that precast, prestressed concrete girders with poured in place concrete deck is more economical than structural steel girders with poured in place concrete deck. The Railroad Company has used prestressed concrete girders of this length and has a slight preference for the concrete because of less maintenance. Precast, prestressed concrete box girders of this length were considered but ruled out as not practical or economical due to their excessive weight (to cast, transport and erect) and due to the fact that most fabricators do not have standard forms or handling equipment for the size of box girders that would be required to support Cooper E-72 loading.

c. Since the permanent railroad bridge replaces a portion of the existing railroad embankment (track on stone ballast) and the policy of the Seaboard Coast Line Railroad is to construct new or replacement bridges with concrete slab ballast deck bridges (track on stone ballast), a ballast deck type superstructure in accordance with the standards of the SCLRR has been indicated. Comparative cost estimates (See Scheme 6 in Appendix "C") indicate that a permanent bridge with steel

girders and timber bridge ties (open-deck) similar to the existing bridge would be slightly more in cost than a concrete ballast deck bridge (See Scheme 5 in Appendix "C"). In addition to being as economical, the ballast deck type bridge requires less bridge maintenance, permits flexibility of ordinary track maintenance (lining and surfacing welded rail track on ballast), and is safer in regard to derailments and hazards of fire.

d. The existing bridge, which would be replaced by the longer proposed bridge, has sufficient capacity to accommodate a design loading equal to Cooper E-74.1 using present design criteria, because the impact effect is less for diesel than for steam engines. Therefore the design loading of Cooper E-72 for the proposed bridge is slightly less than the permitted loading or capacity of the existing Bridge Section No. 8. See Appendix "B" for design computations.

e. The proposed bridge spans the full tailrace canal section. The only restrictions to flow are the seven (7) pier shafts with rounded ends located in the canal section. Calculations indicate that the head loss in the canal flow due to the bridge piers would be approximately 0.017' (3/16") for the maximum discharge of 24,500 cfs and maximum tailwater elevation of 23.4 feet, which is less than the 0.05' (5/8") permissible. Calculations also indicate that scour at the piers would not be significant at the maximum discharge with accompanying velocity of 3.0 feet per second. With tailwater at elevation 11.0, the anticipated flow velocity is 6.0 feet per second and scour at the piers could be expected. Rip-rap protection at the piers is therefore indicated.

21. Factors Considered - Detour Track. Factors considered and route selected for temporary detour track are as follows:

a. Full compliance with AREA and SCLRR requirements for trackwork.

b. A field reconnaissance and the survey data indicate that the amount of earth embankment required and the length of the temporary detour track

would be approximately the same if located on either side of the existing main track. There is an existing dirt access road located on the east side (down stream side) of the main track. The available borrow area for the embankment material is located on the west side (upstream side) of the main track. For these reasons, the west side of the existing track is selected as the route for the temporary detour track. This would also permit the installation of a parallel side ditch on the upstream side to channel the natural flow of water to the opening under the main track provided by Bridge Section No. 7 of the Santee River Bridge. No pipe culverts would be required under the detour track. See Plate 3.

22. Betterments. The proposed facility (bridge over canal) to replace the existing facility (track on earth embankment and Bridge Section No. 8) is not considered a betterment for the following reasons:

a. The proposed permanent bridge with concrete deck, which permits stone ballast and standard timber cross ties, is as economical as a permanent bridge with steel girders and with open-deck consisting of creosoted timber bridge ties, similar to the existing bridge (See 20.c.).

b. The design live loading for the proposed bridge (Cooper E-72) is slightly less than the permitted loading or capacity of the existing bridge (See 20.d.).

23. Frequency and Duration of Flooding at Bridge Site. The existing bridge at the proposed canal crossing is one of several bridges that occur in the railroad embankment as it crosses the Santee River flood plain. Although the top of rail elevation is about two feet above the 50-year flood level, floods with a recurrence interval of slightly less than 25 years reach the bottom of the existing bridge girders. Frequency and duration of

out-of-bank flooding outside the river side levee will not be significantly altered by construction of the new bridge and tailrace canal or by operation of the proposed powerhouse. The tailrace canal follows the south edge of the flood plain and occupies only about 8 percent of the total width of flow as it occurs during flood stages. Also, the remaining openings through the railroad embankment are adequate to pass flood flows with negligible head losses. Inside the proposed tailrace levee and under the new bridge the water levels will be significantly lower for flood flows below about the 50-year event because the river side levee will prevent river flows from entering the tailrace canal. For larger floods the river side levee will be overtopped and the water levels will very nearly match existing conditions.

24. Hydraulic Design Criteria. The following hydraulic data was used in design of the Railroad Bridge:

a. Maximum average velocities in the tailrace canal occur shortly after the powerhouse goes into operation. These velocities reach 6.0 f.p.s. with a coincident water surface elevation of 11.0.

b. Under normal operating conditions (steady state) the water surface elevation is at 22.75 ft. m.s.l. with a design discharge of 24,500 c.f.s. The velocity for this condition is 3.0 f.p.s.

c. The water level would reach the bottom of the bridge beams under conditions caused by backwater from the approximate 40-year flood on the Santee River with the powerhouse operating. Velocities impinging on the bridge under this and greater floods, up to total inundation of the railroad, would be approximately 1.6 f.p.s.

25. Environmental Impact.

a. A final environmental statement on the Cooper River Rediversion Project, which included the Seaboard Coast Line Railroad Bridge, was filed with the Council on Environmental Quality on 14 January 1975.

b. Surface drainage from cuts and fills within the construction limits, whether or not completed, and from borrow and waste disposal areas, would, if turbidity producing materials are present, be held in suitable sedimentation ponds or would be graded to control erosion within acceptable limits. Temporary erosion and sediment control measures such as berms, dikes, immediate seeding of cut and fill slopes, or sedimentation basins, if required, would be provided and maintained until permanent drainage and erosion control facilities are completed

and operative. The area of bare soil exposed at any one time by construction operations would be held to a minimum. Stream crossings by fording with equipment would be limited to control turbidity. Any temporary culverts or bridge structures would be removed upon completion of the project. Fills and waste areas would be constructed by selective placement to eliminate silts or clays on the surface that would erode and contaminate adjacent streams.

GEOLOGY AND SOILS

27. Investigations Performed. Core borings and auger borings have been taken at locations in the vicinity of the proposed structure and borrow area. Failing 314 and Damco 1250 core drills were used. Continuous samples were obtained with a split spoon (1-3/8" I.D. x 2" O.D.) driven with a 140# hammer falling freely 30", and a double tube core barrel with a diamond bit. All materials recovered from drive/core borings were placed in jars or core boxes. Larger volume samples obtained from the proposed borrow area with a 4 x 5-1/2 square auger were placed in bags. Boring locations are shown on Plate 7. Boring logs are shown in Appendix "D".

28. Laboratory Testing. Representative samples from the proposed borrow area were tested by New England Division Laboratory for classification, moisture content and embankment fill properties. Large volume remolded samples from the proposed borrow area were visually classified and subjected to Q and R triaxial shear tests. Consolidation tests were also performed on remolded samples. Laboratory test data are shown in Appendix "D".

29. Compaction of Detour Track Embankment. The embankment material for the detour track would be compacted to a minimum density of 95% of that obtained in a Standard Procter Compaction Test.

30. Bridge Foundation Conditions. A geologic profile of the structure site is shown on Plate 7. Clay, silty clay, silty and clayey sand, clayey silt, and fine and medium sand extends from the ground surface, at approximate elevation 22.0, to the underlying hard layers which begin at elevation 8.0 to 3.0. The hard layers which consist of sandstone at the south end of the bridge and dense silty sand at the center and north end of the bridge have a blow count, obtained by driving the split spoon, in excess of 50 blows per foot up to refusal. This material is too hard or dense to permit the driving of piles. Therefore the piers with foundations below elevation 5.0 would have spread footings on hard material with bearing values of approximately 5.0 tons per square foot. Abutments and piers with footings above elevation 5.0 would be supported on steel H-piles with tips terminating in the hard strata. The steel piles would be

considered end bearing piles with a safe load capacity of approximately 40 tons and would have a minimum length of 10'-0". No load test for the piles is considered necessary since they terminate in hard, dense material.

31. Additional Investigations. Additional subsurface investigations will be performed prior to preparation of final plans. Borings will be made at each pier and abutment location as required to confirm the foundation materials and the footing elevations shown in this design memorandum.

32. Main Track Section. The main track section which is disturbed to permit construction of the new bridge would be designed in accordance with Seaboard Coast Line Railroad Company's standards. The top of the embankment would be 15 feet on each side of the centerline of track for an overall roadbed width of 30 feet. Embankment side slopes would be incorporated into the canal section (canal levee). Four inches of compacted sub-ballast and 6 inches minimum of compacted stone ballast would be used for a minimum depth of 10 inches from the top of roadbed to the bottom of cross ties. On the bridge structure, 8 inches minimum of stone ballast would be used from the top of the concrete deck to the bottom of cross ties. Graded granite ballast and crusher-run granite sub-ballast would be used. Sub-ballast would be furnished and placed by the Government's contractor.

33. Detour Track Section. The top of the detour track embankment would be 12 feet on each side of the centerline of track for an overall roadbed width of 24 feet. Embankment side slopes would be 1.5H:1V with an 18 foot (min.) wide berm at natural ground adjacent to the excavation for the canal under the new bridge. Slope stability calculations indicate that the proposed detour embankment constructed on the existing ground materials consisting of clay, silty clay, silty and clayey sand, clayey silt, and fine and medium sand extending from ground surface to the underlying hard strata would have the following minimum factors of safety against a shear failure. For the End of Construction Condition (Plate 8) the factor of safety would be 1.60 which is larger than the 1.3 required for permanent embankments. For the Sudden Drawdown Condition (Plate 9) the factor of safety would be 1.39 which is larger than the 1.2 required for permanent embankments. Ponded water would be drained and unsuitable foundation materials removed before placement of detour embankment. The section for crusher-run granite sub-ballast and graded granite ballast would be the same as for the main track section. The proposed alignment provides for 160 foot spirals and 2°-00' curves. The maximum distance between the centerlines of the detour track and main track would be 137.64 feet. The detour track embankment would remain in place with the canal construction contractor removing the portion as required to provide the final tailrace canal and levee cross section.

34. Canal Excavation. A 50 foot length (measured along the bottom of canal) of the proposed tailrace canal would be excavated under the new bridge in connection with this project. Unsuitable material would be placed in nearby disposal areas to be acquired for the tailrace canal. Suitable excavated material would be placed to form a portion of the permanent canal levees adjacent to the bridge. Excavation of this portion of the proposed canal permits installation of the stone rip-rap under the new bridge and eliminates the need for canal excavation under the new bridge after it is placed in operation and carrying rail traffic. Additional rip-rap for canal berm and slope protection at the vicinity of the bridge would be placed by the canal construction contractor. The typical section of the canal in the vicinity of the new bridge has a 285 foot bottom width at elevation 0.0 (M.S.L.) and 3:1 side slopes up to a 30 foot wide berm at elevation 26.0. The normal berm at elevation 26.0 is 90 feet wide except at the bridge. Above the berm at elevation 26.0, 3:1 or 4:1 side slopes extend to the top of the levee. The top width of the levee is 20'-0" with 3:1 or 4:1 back slopes. The normal top of levee elevation is elevation 43.0 on the north side and elevation 35.0 on the south side. At the railroad, the top of levees would rise to the top of rail elevation for crossing the railroad at grade. These crossings would provide continuous travel for inspection vehicles along the top of the levees which act as patrol roads. The railroad would be protected by locked gates at each crossing.

35. Bridge. The proposed bridge would have 8 interior spans at 63'-3", one 41'-0" approach span on the north end and one 43'-0" approach span on the south end for an overall length of bridge of 590'-0" face to face of backwalls. Each span would consist of 4 precast, prestressed concrete girders with a poured-in-place reinforced concrete deck slab and ballast curbs. These span lengths leave the 30 foot berm at elevation 26.0 free of obstruction. The canal piers would be reinforced concrete piers with spread footings on hard material. Bottom of footing for the canal piers would be at approximate elevation -5.0. Excavation and construction of the intermediate canal piers would be inside cofferdams to permit open construction as the ground line and water table are at approximate elevation 21.0. The

abutments and end piers would be reinforced concrete with pile foundations. Two refuge or safety platforms would be provided outside the bridge deck for use by railroad personnel. Drainage would be provided with cast iron downspouts cast in the concrete deck slab and extending below the girders. Stone rip-rap would be placed on the side slopes and canal berms at each end of the bridge to protect them from scour and erosion. Berms and slopes outside of the bridge limits would be protected by vegetation. The existing bridge superstructure and substructure would be completely removed, except for the existing north abutment which would be removed only as necessary to construct the new bridge. All salvage from the existing bridge would become the property of the contractor and its value would be taken into consideration. Details of the proposed bridge are shown on Plates 5 and 6.

36. Track Materials. Track material for the detour track (jointed rail, track hardware, timber cross ties, etc.) would be furnished and installed in accordance with AREA and/or Seaboard Coast Line Railroad requirements. If a turnout is used at one end of the detour track to allow access to the construction site for delivery of materials, it would be in accordance with SCLRR requirements. Use of a turnout would be determined at time of contract, based on construction requirements. The welded rail, track hardware and timber cross ties within the area of the new bridge would be removed to permit construction and relayed across the new bridge with such additional timber cross ties as required. New timber cross ties (track ties) would be required for the section of the track that is now supported by Bridge Section No. 8 (bridge ties on steel girders). Any cross ties in the existing track rendered unusable due to disturbance would be replaced as part of project cost. Timber cross ties for the detour track and the permanent track would be spaced at 21 inch centers.

37. Borrow Area. The proposed borrow area for the detour embankment material is located approximately 1000 feet west of track station 12+00 (coordinates N 580,850, E 2,329,850). This area is high ground located at the edge of the river flood plain (from flood plain elevation of 22.0 to elevation 43.0). Core borings indicate that this material is tan sandy

clay and white to light gray silty sand with an average blow count of 30. The water content of the material for maximum density is approximately 14% of dry weight which is approximately the average water content in the natural state. The depth of cut in the borrow area to provide the amount of material needed is approximately 10.0 feet. The maximum haul distance would be approximately 3,000 feet and the minimum haul distance would be approximately 800 feet. The location of the proposed borrow area is shown on Plate 2. The obtaining of the detour embankment material from the proposed canal excavations is not recommended since the canal excavations are below the ground water table and would require drying before the water content for maximum compaction and density is obtained.

38. Construction Time. The estimated construction time is 550 calendar days.

39. Construction Procedure and Sequence. The anticipated construction procedure and sequence is as follows:

a. Place SCLRR communication line in temporary location.

b. Construct detour track embankment including drainage ditch.

c. Construct detour track and place in service.

d. Remove existing track, existing bridge, and existing embankment for construction of proposed bridge.

e. Install cofferdams and construct proposed bridge complete.

f. Excavate portion of canal under bridge and complete portion of levees at railroad. Install rip-rap.(Based on bridge constructed before canal).

g. Replace track across new bridge and complete grade crossings.

h. Place rail traffic on original alignment across new bridge. Place communication line in permanent location.

ESTIMATED COST

40. Summary Project Cost Estimate.

COOPER RIVER REDIVERSION PROJECT
RELOCATION OF SEABOARD COAST LINE RAILROAD BRIDGE

Summary Project Cost Estimate
(July 1976 Price Levels)

Cost Account No.	Item or Feature	Current Cost Estimate
02.	Relocations	$1,340,000
30.	Engineering and Design (9.0%)	121,000
31.	Supervision and Administration (7.0%)	94,000
	Total Cost	$1,555,000

41. Detailed Cost Estimate (July 1976 Price Levels)

Feature	Unit	Quantity	Unit Price	Total Cost
Detour Facilities				
Construct Access Roads	L.S.	Job	-	$ 5,000
Clearing (Detour Embankment)	Acre	7.5	1,600.00	12,000
Clearing & Grubbing (Borrow Area)	Acre	7.5	1,300.00	9,750
Excavation of Unsuitable Material (Detour Embankment)	C.Y.	13,000	3.10	40,300
Excavation - Drainage Ditch	C.Y.	5,500	3.10	17,050
Detour Embankment (In Place)	C.Y.	93,400	1.90	177,460
Sub-Ballast (In Place)	Ton	880	7.00	6,160
Stone Ballast (In Place)	Ton	1,420	8.00	11,360
Detour Track (Constr. & Remove)	Tk. Ft.	2,150	40.00	86,000
Seeding & Grassing	Acre	16	1,700.00	27,200
Permanent Bridge				
Miscellaneous Items:				
Main Track - Remove & Relay	Tk. Ft.	700	15.00	10,500
Main Track - To Be Raised	Tk. Ft.	1,000	2.00	2,000
Excavation-Main Track Embankment at Bridge - (Construction of Levees)	C.Y.	11,920	1.50	17,880
Excavation - Tail-race Canal at Bridge (Construction of Levees)	C.Y.	25,700	2.00	51,400
Grade Crossings (Incl. Gates)	Each	2	1,500.00	3,000
Sub-Ballast (In Place)	Ton	40	10.00	400
Timber Cross Ties (To Replace Timber Bridge Ties)	Ea.	200	12.50	2,500

Feature	Unit	Quantity	Unit Price	Total Cost
Stone Ballast (In Place)	Ton	560	12.00	$ 6,720
Removal of Existing Bridge	L.S.	Job	-	26,000
Stone Rip-Rap	Ton	1,450	25.00	36,250
Bridge Sub-Structure:				
Cofferdams	Each	7	14,000.00	98,000
Structure Excavation (Piers and Abutments)	C.Y.	2,990	20.00	59,800
Steel Piles HP 12x53	L.F.	890	15.00	13,350
Concrete	C.Y.	970	130.00	126,100
Reinforcing Steel	Lb.	91,600	.30	27,480
Bridge Super-Structure:				
45" Prestressed Concrete Girders	L.F.	335	65.00	21,775
54" Prestressed Concrete Girders	L.F.	2,015	75.00	151,125
Concrete	C.Y.	326	160.00	52,160
Reinforcing Steel	Lb.	74,460	.30	22,338
Structure Drainage System	L.S.	Job	-	8,000
Waterproofing & Dampproofing	L.S.	Job	-	7,000
Work to be Performed by SCLRR				
Trackwork (Line Track, Maintain Detour Track, Cut & Weld Rail)	L.S.	Job	-	12,400
Signal & Communication Work (Pole Line, Bond Track, Etc.)	L.S.	Job	-	9,400
Inspection Service	L.S.	Job	-	17,300
Watchman and/or Flagging Service	L.S.	Job	-	11,000
Engineering (Coordinate, Review, Etc.)	L.S.	Job	-	8,800
Accounting	L.S.	Job	-	1,100
	Sub-Total			$1,196,058
	Contingencies (12%)			143,942
	Construction Cost			$1,340,000

42. Cost Analysis.

a. Comparison of cost with previously presented estimates:

ITEM	DESIGN MEMORANDUM EST. Presented herein July 1976	CURRENT APPROVED PB-3 Estimate
Relocation of SCL RR Bridge	$1,340,000	$3,010,000

All costs are exclusive of land cost and include 12 percent contingencies.

b. Explanation of differences in cost estimates:

The reduction in estimated cost is due primarily to the following:

1. Decrease in length of bridge due to reduction in bottom width of canal.

2. Decrease in length of detour facilities due primarily to more detailed design.

3. Utilization of spread footings in lieu of pile foundations for 7 intermediate piers in canal.

4. Utilization of precast, prestressed concrete girders for superstructure with economical span lengths for approximate balance between superstructure cost and substructure cost.

CONCLUSIONS & RECOMMENDATIONS

43. Conclusions.

a. This memorandum is in accord with minimum relocation DM requirements listed in letter by SADEN-GK, dated 22 January 1975. The proposed plan of relocation has been developed within the guidelines of ER 1180-1-1 to provide substitute facilities which will compensate the Seaboard Coast Line Railroad for detrimental project effects to their facilities. The plan is substantially the same as for the GDM.

b. The relocation plan contains one major relocation at an estimated construction cost of $1,340,000 which would restore the affected SCL facilities to comparable pre-project conditions. The proposed relocation has been developed in appropriate coordination with other affected project features and the overall project plan.

c. SCL Railroad officials generally concur with the plan of relocation as presented herein. They have indicated a preference that the Government have basic responsibility for performing design and construction of the relocation. However, the railroad may, depending on their labor arrangements at the time of construction, perform all trackwork above sub-ballast and any communications and signal work involving their own facilities. See Exhibits 1 through 4 for correspondence with the Seaboard Coast Line Railroad Company.

d. All construction and design work would be at the expense of the Government. No betterments are involved in the proposed relocation plan.

e. Basis for settlement for the railroad relocation will be by a Cost Reimbursable (Mutual Covenants) Contract Form ECI A-308. The contract will provide: (1) for payment to the railroad for any work they perform and (2) for the relocation work as an exchange in compensation for detrimental project effects to the railroad and for real estate rights from the railroad as necessary to construct, operate and maintain the project.

44. Recommendation. It is recommended that relocation plan and attendant information presented in this memorandum be approved as a basis for this office to subsequently negotiate a contract, develop contract plans and specifications, and perform ultimate construction for the relocation.

EXHIBITS

SACEN-GS 30 April 1976

Mr. T. B. Hutcheson
Assistant Vice President
Seaboard Coast Line Railroad Company
Engineering Department
500 Water Street
Jacksonville, Florida 32202

Dear Mr. Hutcheson:

This concerns our proposed plan of remedial work to your facilities as part of the Cooper River Rediversion Project near St. Stephen, S.C. The proposed tailrace canal alignment for the project will cross the SCL Railroad north of St. Stephen, S.C. at Milepost A-347.96. This will require the construction of a single-track railroad bridge to provide the opening through the existing railroad embankment and the area occupied by the existing 282.0-foot long railroad bridge designated as Section No. 8 of the SCL Railroad Bridge over Santee River.

We are nearing the final stage of our work on the detailed design memorandum (DDM) in which we will present details of the proposed work for review and approval by our higher authority. It is essential in preparing the report to assure that the proposed plan has been coordinated with the facility owner; the owner's views are thoroughly considered in the plan development; and the owner's expressed opinion is documented in the report. Accordingly, this letter and its inclosures are furnished to acquaint you with our proposed plan of work for your facilities and solicit your related approval and/or comments.

Attached are four (4) copies of pertinent excerpts from the DDM draft and four (4) prints each of Plates 1 through 7 showing the existing conditions and the proposed canal, bridge and temporary detour track as well as other pertinent aspects. As a result of informal contacts with your staff and prior experience in designing your facilities by our consultant, Ralph Whitehead & Associates, we believe that the design and details indicated on the plans for the proposed bridge and temporary detour track are in accordance with your requirements for track and bridges. The proposed bridge would consist of reinforced concrete piers and abutments, precast prestressed concrete girders, and reinforced concrete deck slab. The

EXHIBIT 1

temporary detour track to permit construction would be on the west or upstream side of the existing track.

Please note that the top of the canal levees would rise at the railroad to the top of rail elevation for crossing the railroad at grade. These crossings are necessary to permit inspection vehicles to operate along the top of the levees. The railroad would be protected by locked gates at each crossing.

Concrete cross ties have been indicated for the track on the proposed bridge. Since the concrete ties will replace the existing timber cross ties and bridge ties, we are requesting that the concrete ties and fasteners be furnished by and at the expense of the Seaboard Coast Line Railroad for installation by and at the expense of the Government or its contractor. The existing timber cross ties and bridge ties will remain the property of the Seaboard Coast Line Railroad but will be removed and stockpiled by the Government's contractor. We are proposing that all other costs involved in the project would be borne by the Government . Any salvageable material from the completed work, except as mentioned above, would become the property of the Government or its contractor.

Please consider our proposed plan of remedial work and return one set of the inclosed plans along with your appropriate written comments. Your views will be included in our final development of the DDM.

I would point out that the DDM, as approved, will become the basis for negotiating a formal relocation contract with you for ultimate final design and construction of indicated alterations. You will also be given the opportunity to approve subsequent contract plans and appropriately inspect and otherwise participate in the ultimate construction.

I would appreciate your timely consideration of this matter. Any additional detailed information, if needed, can be obtained by calling my personal representative, Mr. Joe Whetstone, at (803) 577-4171, Ext. 285. If, after reviewing the inclosed information, you feel a meeting of our appropriate representatives to discuss this matter would be helpful or if I can otherwise be of personal assistance, please let me know.

Sincerely,

2 Incls (quad)
As stated

HARRY S. WILSON, JR.
Colonel, Corps of Engineers
District Engineer

SEABOARD COAST LINE RAILROAD COMPANY

Engineering Department
Jacksonville, Florida 32202

T. B. HUTCHESON
ASSISTANT VICE PRESIDENT

TELEPHONE 353-2011
AREA CODE 904

May 4, 1976 A 347.9-TB

Mr. Harry S. Wilson, Jr.
Colonel, Corps of Engineers
District Engineer
Charleston District Corps of Engineers
P. O. Box 919
Charleston, S. C. 29402

Sir:

This is an acknowledgement of your letter of 30 April, 1976, File SACEN-GS, advising that the detailed design memorandum for the Cooper River Rediversion Project near St. Stephen, S. C. is in its final stage of development.

The excerpts from the DDM draft and prints of drawings detailing the proposed canal, bridge and detour facility, forwarded with your letter, will be reviewed by the affected departments of the Railroad. You can expect a prompt response since a cursory inspection of the material indicates an excellent and clear presentation of the proposed project.

Yours very truly,

T. B. Hutcheson

Assistant Vice President

EN/id

EXHIBIT 2

SEABOARD COAST LINE RAILROAD COMPANY

Engineering Department
Jacksonville, Florida 32202

T. B. HUTCHESON
ASSISTANT VICE PRESIDENT

TELEPHONE 353-3011
AREA CODE 904

June 1, 1976 A 347.9-TB

Harry S. Wilson, Jr., Colonel
Corps of Engineers
District Engineer
Charleston District Corps of Engineers
P. O. Box 919
Charleston, S. C. 29402

Sir:

Please refer to your letter of 30, April, 1976, File SACEN-GS, with which you forwarded selected preliminary drawings and Detailed Design Memorandum Excerpts for Cooper River Rediversion Project near St. Stephen, South Carolina.

As stated in our response of May 4, this is an excellent preliminary presentation and consequently we have only a few minor suggested changes.

Primary among the changes is the removal and installation of all track work above subballast-both detour and permanent-must, at the present time, due to our current labor arrangements, be an optional responsibility of the Railroad.

Further, in reference to the track work items, we desire that both permanent and detour ties be standard timber track ties on 21-inch centers. This will eliminate any need for concrete ties on this project. We also believe that it would be desirable to install a No. 10 turnout at one end of the detour track to allow access to the construction site for delivery of materials. A line sketch of such a turnout layout is attached to Plate No. 3.

An additional item that must be considered is the communications and signals facilities will require temporary plant arrangement prior to construction and restoration to permanent plant after the bridge is completed.

EXHIBIT 3

There are several other minor items noted on the drawings which we believe are all self explanatory.

Assuming that the necessary permits could be obtained, we are curious if a surplus of fit material from the canal excavation would be available for use by the Railroad in filling portions of some of the several other openings that the SCL maintains on this trackage. Your advice in this regard would be appreciated.

This office remains, at your convenience, available for further explanation or verification of the above comments.

Yours very truly,

T.B. Hutcheson

Assistant Vice President

EN/id

DEPARTMENT OF THE ARMY
CHARLESTON DISTRICT, CORPS OF ENGINEERS
P. O. BOX 919
CHARLESTON, S.C. 29402

SACEN-G

17 June 1976

Mr. T. B. Hutcheson
Assistant Vice President
Seaboard Coast Line Railroad Company
Engineering Department
500 Water Street
Jacksonville, Florida 32202

Dear Mr. Hutcheson:

Thank you for your timely comments on the excerpts and plates from the Detailed Design Memorandum (DDM) draft pertaining to the relocation of your facilities that will be affected by the Cooper River Rediversion Project.

All of your comments will receive our utmost consideration in final development of our proposed relocation plan. Your views do not indicate any serious problems for us. However, if some question of concurrence develops with your expressed views the problem area will be clearly identified for consideration by our higher authorities during the review and approval process of the DDM. You will be appropriately informed of the results prior to final design of the relocation. Your letter will be presented as an exhibit in the DDM.

Regarding your interest in acquiring surplus fill material from the canal excavation, we prefer that this matter be handled directly by you with our Canal Contractor at an appropriate time after beginning of construction of the tailrace canal. This would permit a better opportunity to more realistically arrange for this work based on better assessments of type, quantity and availability of the earth material. We will be pleased to advise our Contractor of your interest in obtaining the fill material from the canal excavation and request his cooperation in making mutually reasonable arrangements with you to satisfy your fill requirements. I believe the greatest concern with this is whether or not enough of the excavated canal material will be suitable and conveniently available for your purposes.

EXHIBIT 4

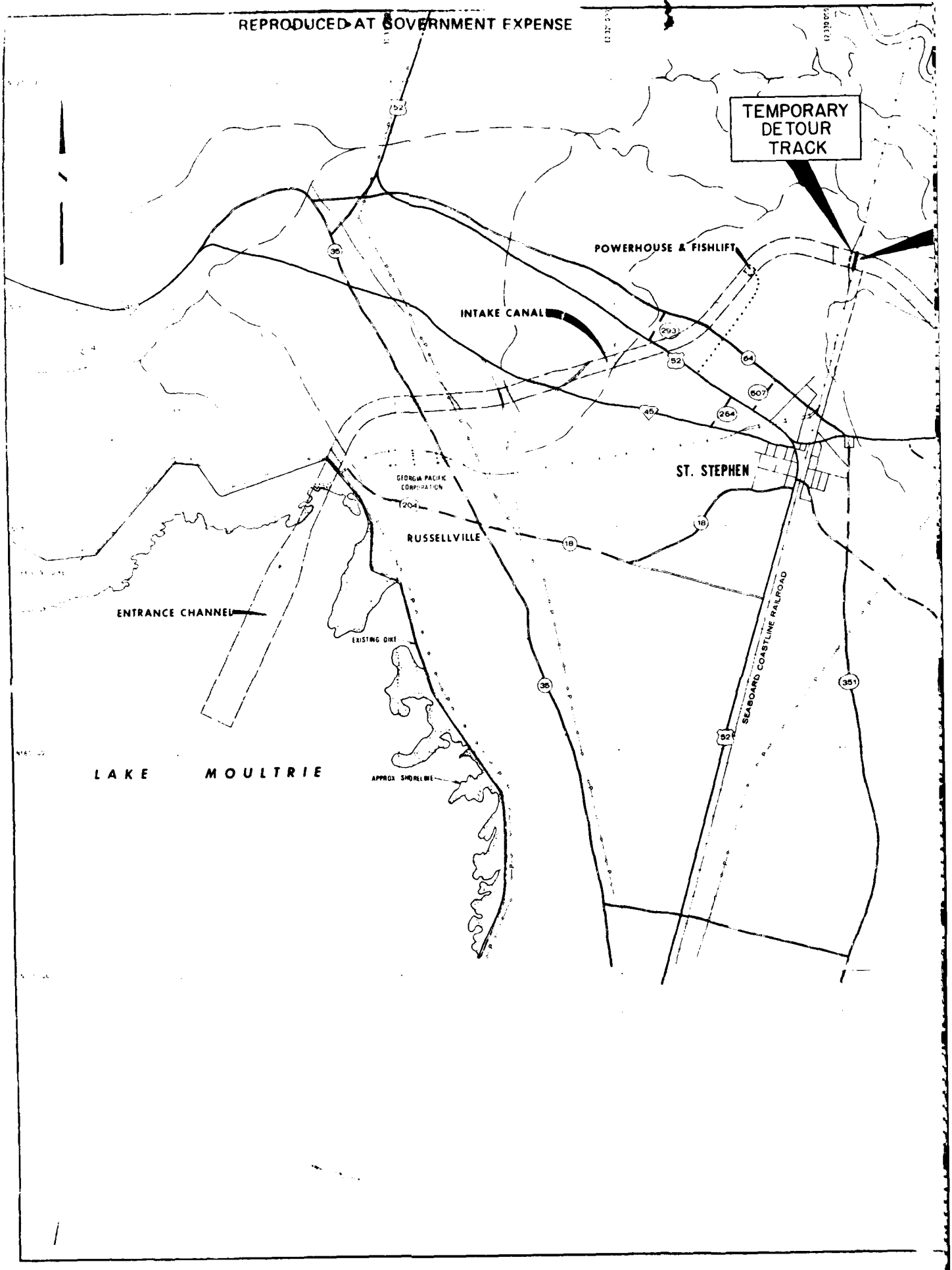
SACEN-G 17 June 1976
Mr. T. B. Hutcheson

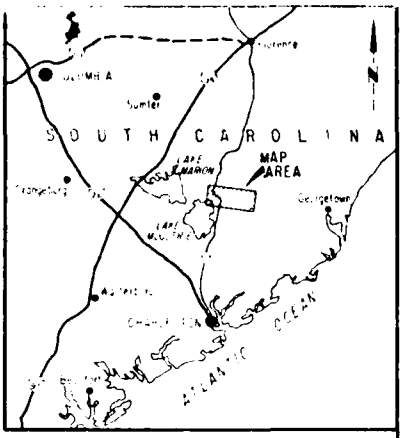
Please be assured of our concern for your facilities at the project and our intent to cooperate with you to accomplish necessary changes with minimum disruption to your operations. We will keep you informed of our continuing actions concerning your facilities and the project.

Sincerely,

for Dale P. Gregg
Lt. Colonel, Corps of Engineers
Acting District Engineer

PLATES





RARY
UR
CK

S.C.L. RAILROAD BRIDGE

Santee

TAILRACE CANAL

LAKE MATTASEE

River

SCALE IN FEET
SCALE RATIO 1:25,000

NOTES

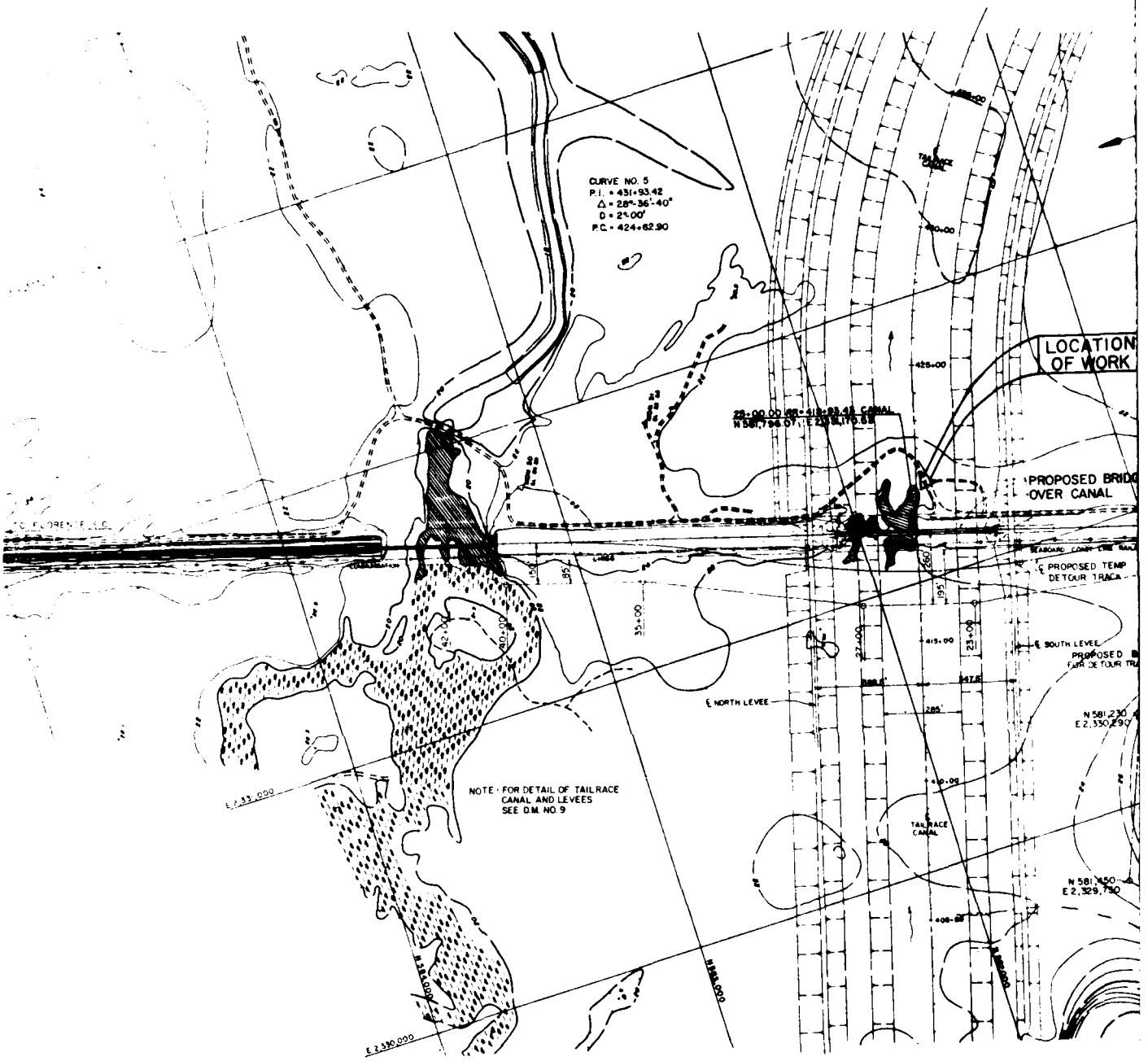
GRID SHOWN IS BASED ON NORTH CAROLINA STATE PLANE COORDINATE SYSTEM

LEGEND

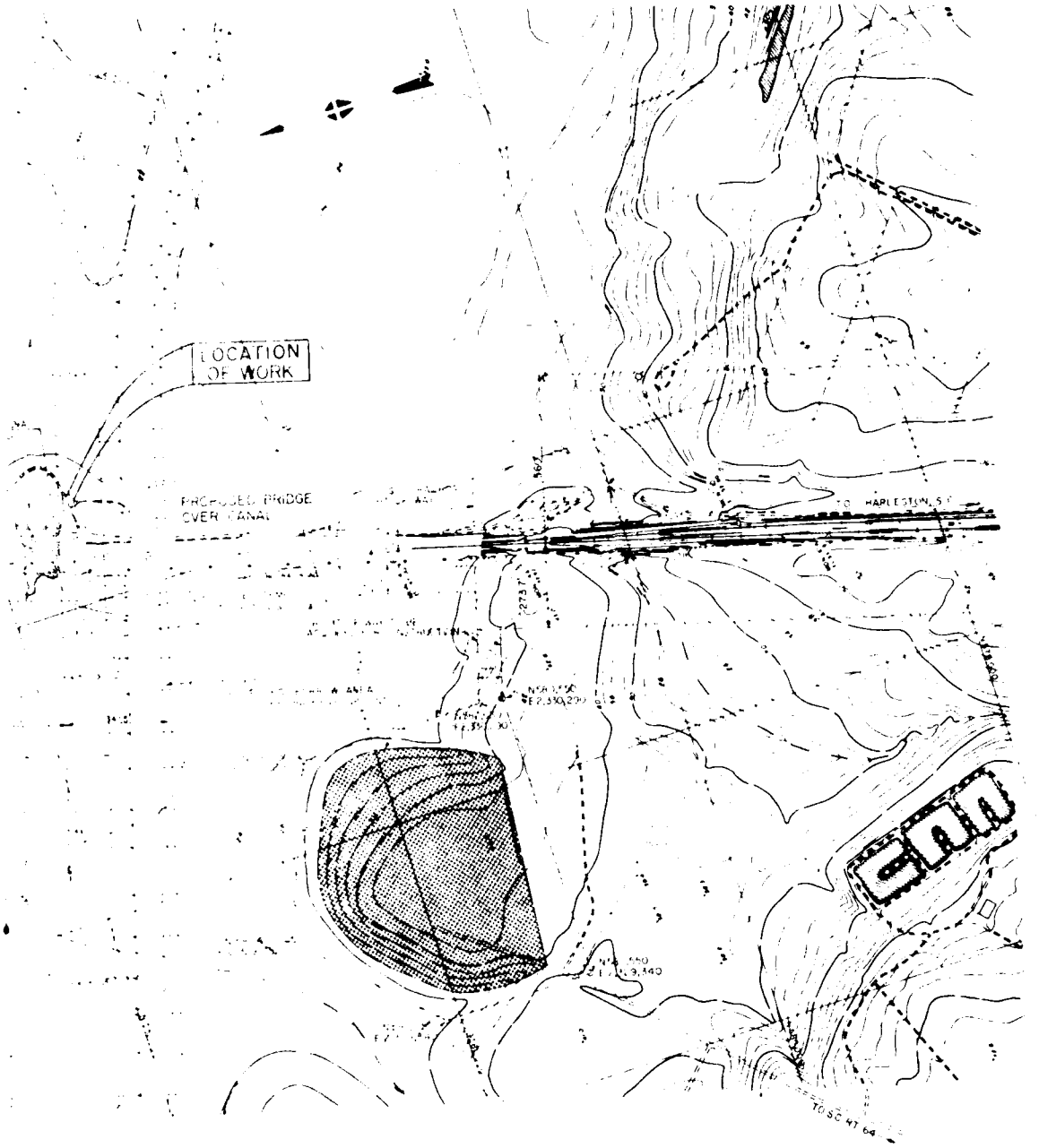
- U.S. HIGHWAY PRIMARY
- STATE HIGHWAY PRIMARY
- STATE HIGHWAY SECONDARY
- POWER TRANSMISSION LINE
- IMPROVED LIGHT DUTY ROAD
- UNIMPROVED DIRT ROAD & TRAIL
- STREAM
- NEW [illegible] ROAD
- LAND SUBJECT TO INUNDATION

RELOCATION OF
SEABOARD COAST LINE RAILROAD BRIDGE
LOCATION PLAN
COOPER RIVER REDIVERSION PROJECT
LAKE MOULTRIE & SANTEE RIVER SOUTH CAROLINA

	DESIGN MEMORANDUM NO. 8	PLATE 1



REVISIONS DESCRIPTION	BY	DATE



800 FEET

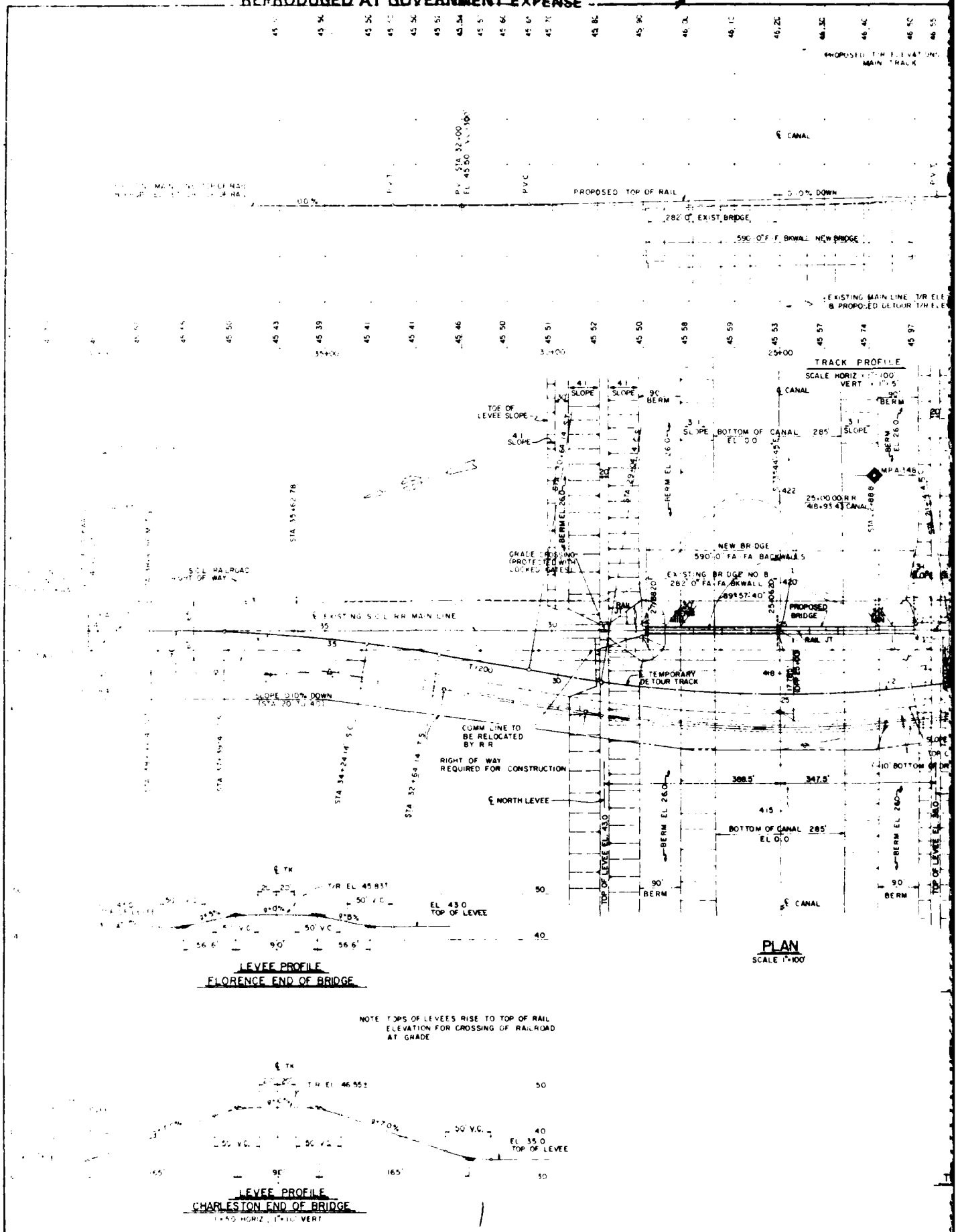
ARMY ENGINEER DISTRICT, CHARLESTON
CORPS OF ENGINEERS
CHARLESTON, SOUTH CAROLINA

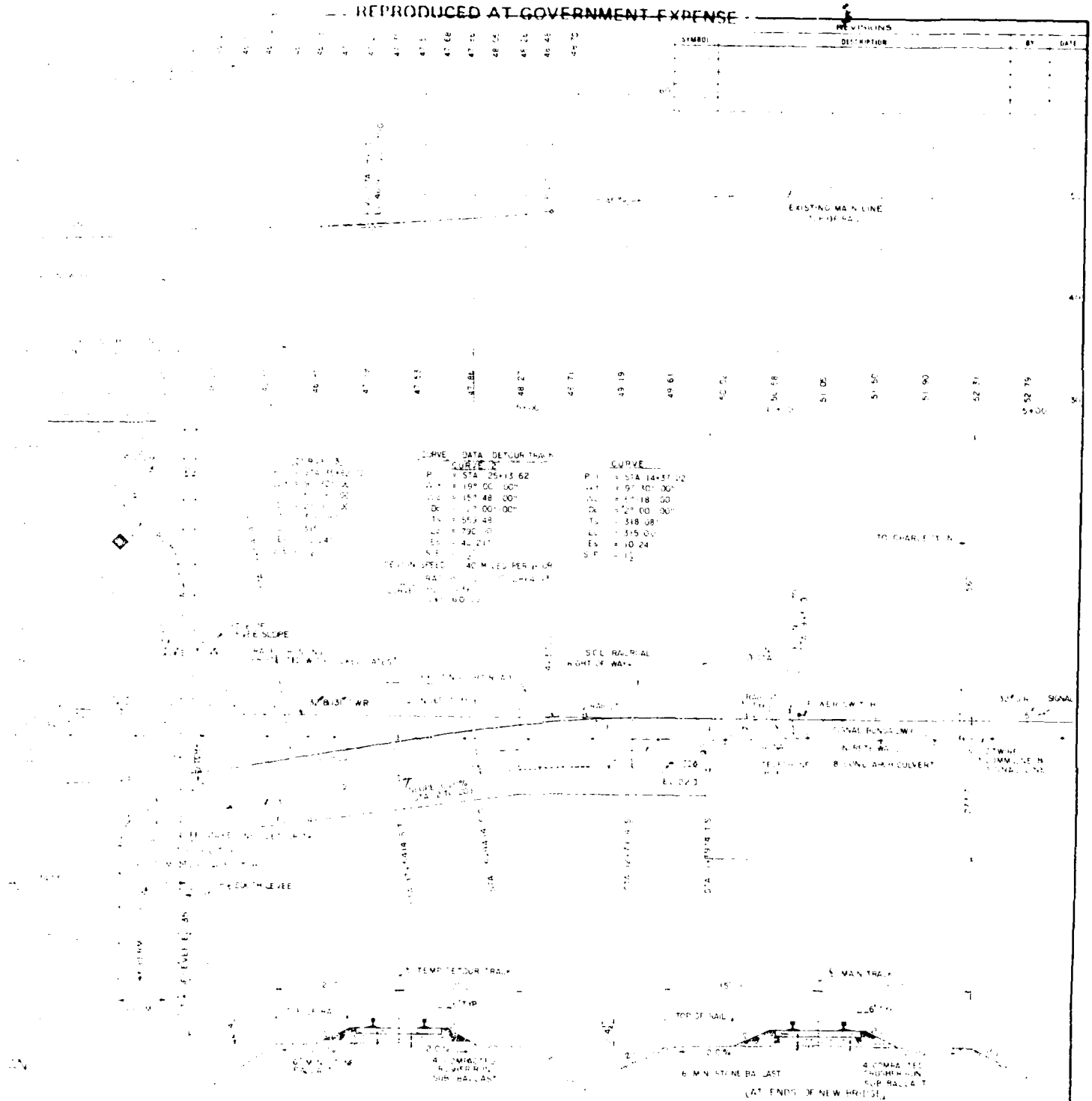
RELOCATION OF
SEABOARD COAST LINE RAILROAD BRIDGE

SITE PLAN

COOPER RIVER, RE-EVALUATION PROJECT
LAKE MOULTRIE AND SANTEE RIVER, SOUTH CAROLINA

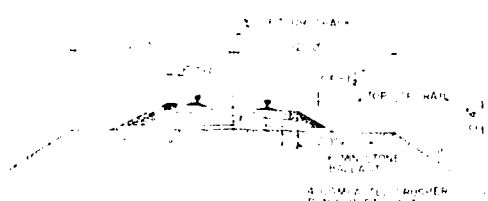
SCALE 1" = 200'	DESIGN MEMORANDUM NO. 8	PLATE 2
DATE JULY 1976		FILE NO. 10042





TYPICAL ROADBED SECTION FOR TEMPORARY DETOUR TRACK

TYPICAL ROADBED SECTION FOR RECONSTRUCTED MAIN TRACK



TYPICAL ROADBED SECTION FOR [illegible] ELEVATED TEMPORARY DETOUR TRACK

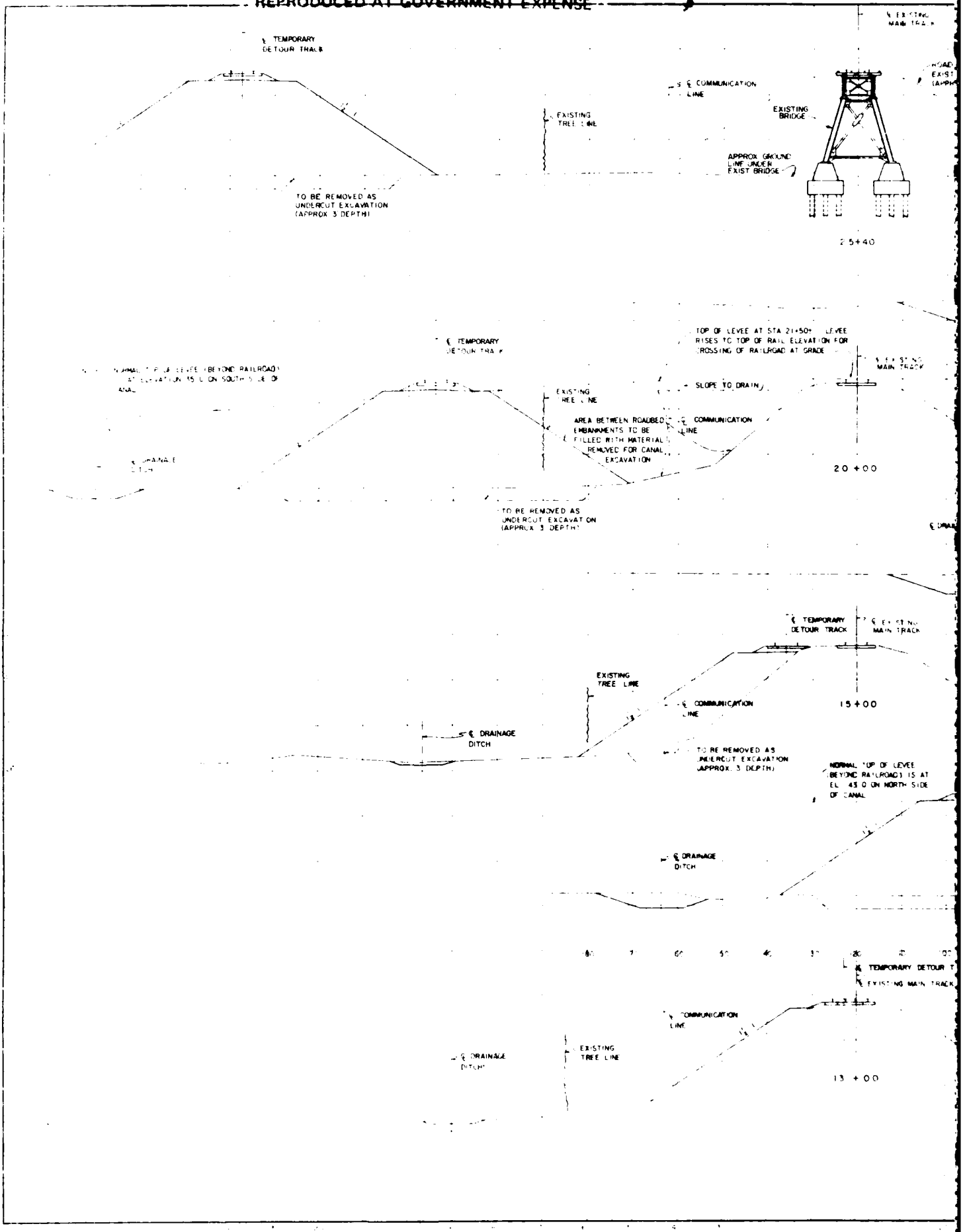
U.S. ARMY ENGINEER DISTRICT, CHARLESTON
CORPS OF ENGINEERS
CHARLESTON, SOUTH CAROLINA

RELOCATION OF
SEABOARD COAST LINE RAILROAD [illegible]

TRACK PLAN, PROFILE & SECTIONS

COOPER RIVER RESCUE [illegible]
LAKE MOULTRIE, BERKELEY COUNTY, SOUTH CAROLINA

SCALE AS SHOWN	DESIGN MEMORANDUM NO. 8	PLATE 5
DATE JULY 1976		[illegible]



REVISIONS

SYMBOL	DESCRIPTION	BY	DATE

EXISTING EMBANKMENT BEHIND
EXISTING ABUTMENT
(APPROX ELEV 15.0)

TEMPORARY
DETOUR TRACK

EXISTING
TREE LINE

COMMUNICATION LINE

EXISTING
DIRT ROAD

DRAINAGE
DITCH

37+00

EXISTING
DIRT ROAD

TEMPORARY
DETOUR TRACK

EXISTING
TREE LINE

COMMUNICATION
LINE

35+00

EXISTING
DIRT ROAD

TO BE REMOVED AS
UNDERCUT EXCAVATION
(APPROX 3' DEPTH)

EXISTING
DIRT ROAD

AREA BETWEEN RAILROAD EMBANKMENTS
TO BE USED FOR MATERIAL REMOVED
FOR FINAL EXCAVATION

COMMUNICATION
LINE

30+00

EXISTING
DIRT ROAD

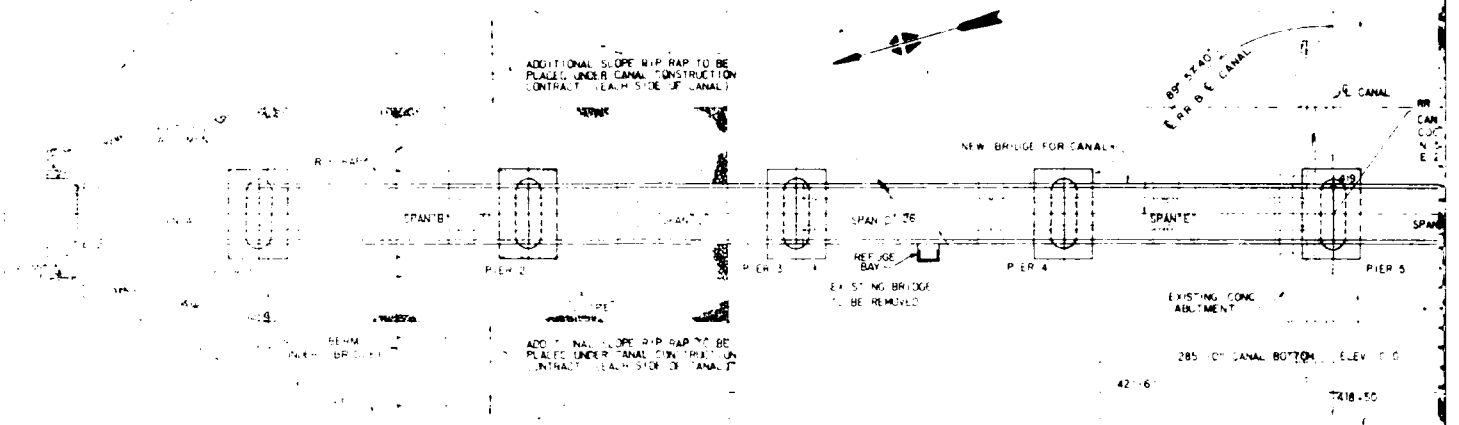
EXISTING
TREE LINE

TO BE REMOVED AS
UNDERCUT EXCAVATION
(APPROX 3' DEPTH)

RELOCATION OF
RAILROAD

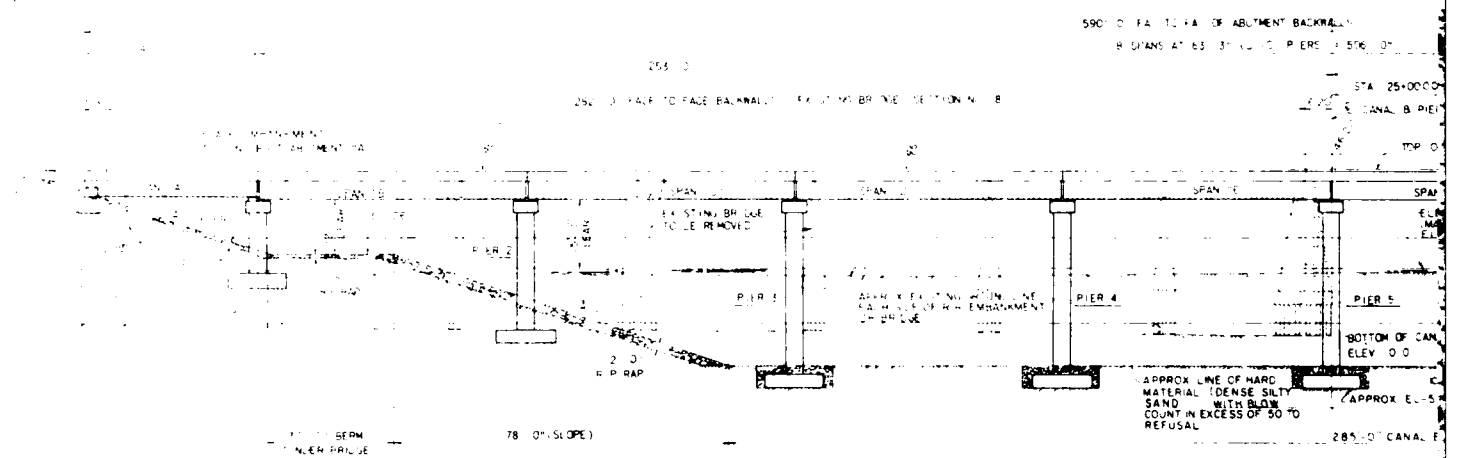
RAILROAD CROSS SECTIONS

MEMORANDUM
NO. 8



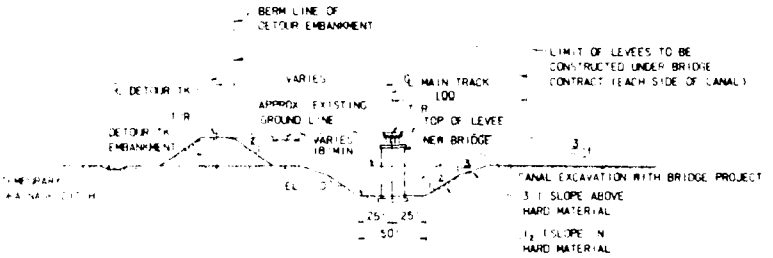
PLAN

SCALE 1" = 6'-0"



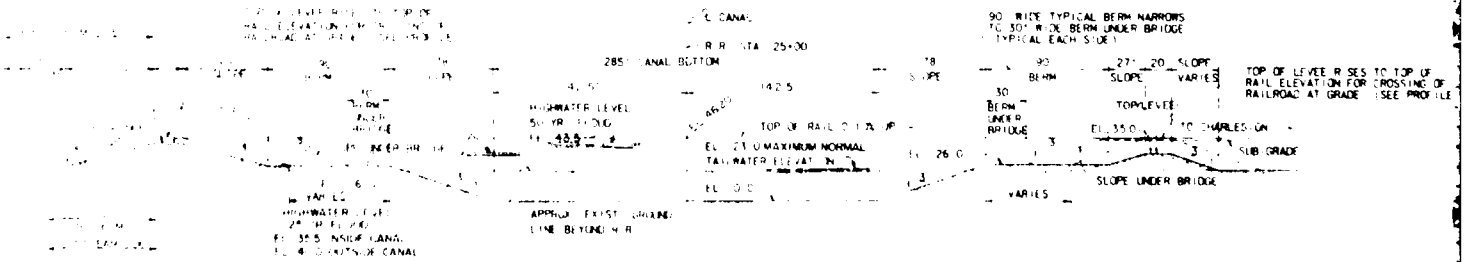
ELEVATION

SCALE 1/16"=1'-0"



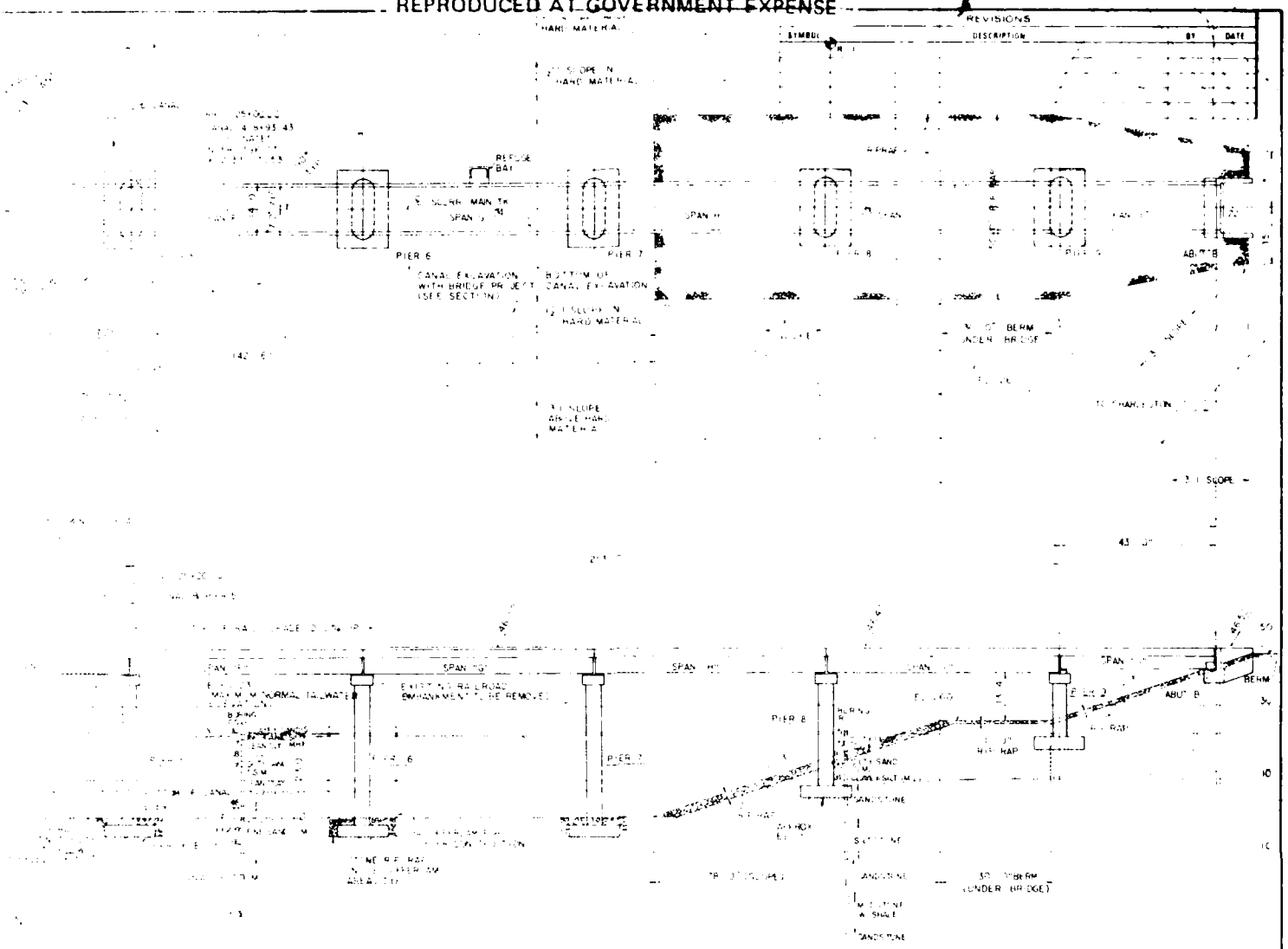
SECTION FOR CANAL EXCAVATION AT BRIDGE

SCALE



TYPICAL CANAL SECTION NEAR RAILROAD BRIDGE

SCALE



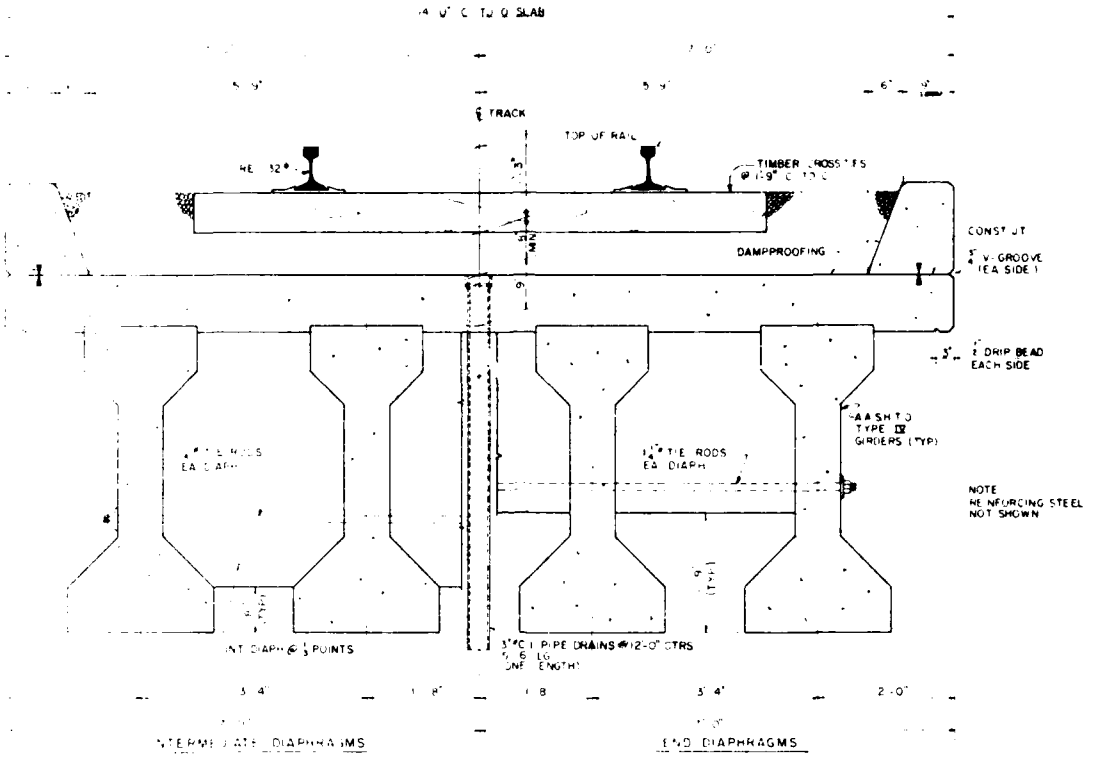
U.S. ARMY ENGINEER DISTRICT, CHARLESTON
CORPS OF ENGINEERS
CHARLESTON, SOUTH CAROLINA

RELOCATION OF
NEAB AND COAST LINE RAILROAD BRIDGE

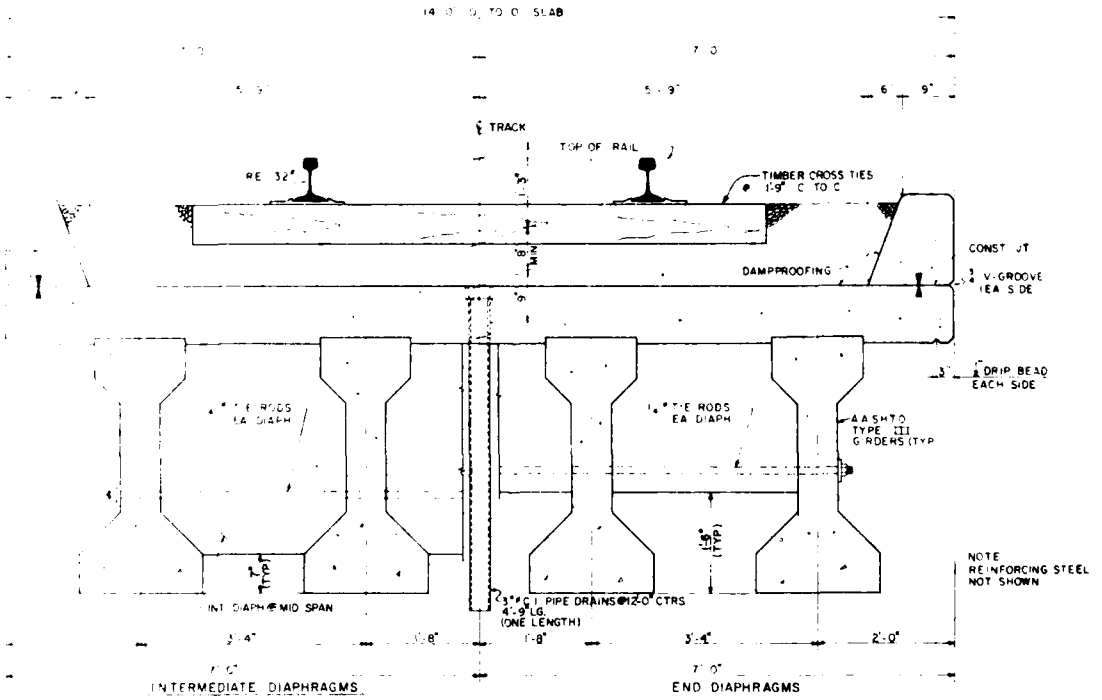
PLAN AND ELEVATION OF BRIDGE

COOPER RIVER, REVERSION TO 1968
LAKE MOULTRIE AND SANTEE RIVER, SOUTH CAROLINA

SCALE AS SHOWN	DESIGN MEMORANDUM NO. 8	PLATE A
DATE JULY 1976		FILE NO. 0042

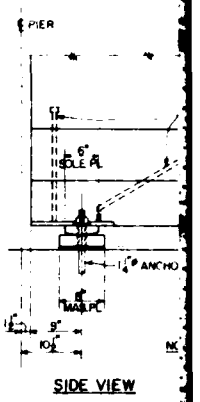


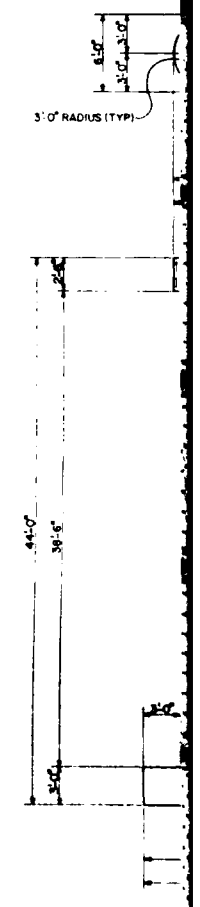
INTERIOR SPANS
SPAN LENGTHS 63'-3", 8 SPANS



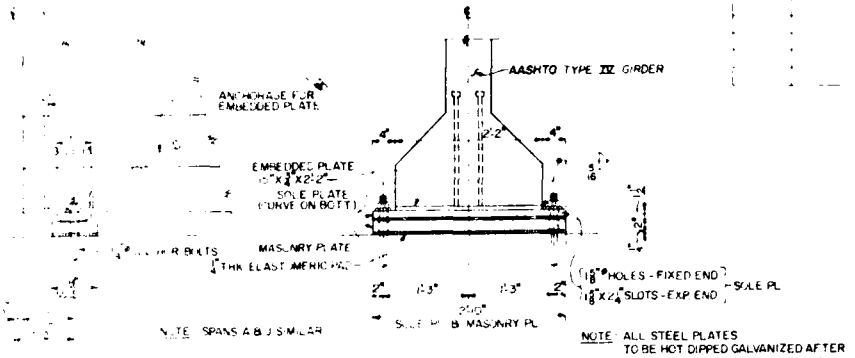
END SPANS
1 SPAN 41'-0" AND 1 SPAN 43'-0"

TYPICAL DECK SECTION





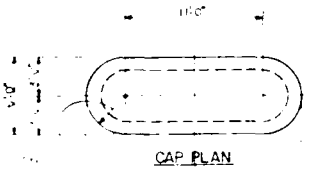
REVISIONS			
SYMBOL	DESCRIPTION	BY	DATE



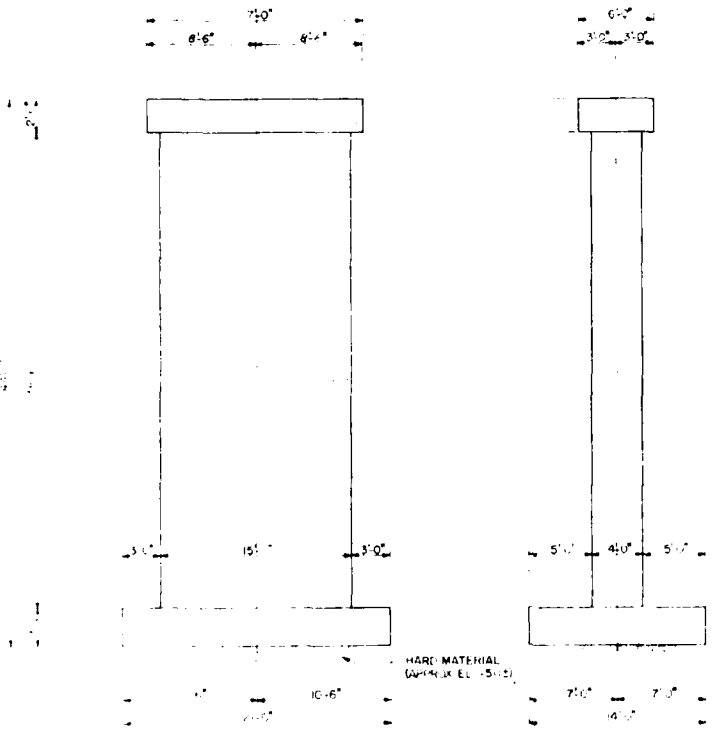
END VIEW

NOTE: ALL STEEL PLATES TO BE HOT DIPPED GALVANIZED AFTER FABRICATION. FIELD WELDS TO BE PAINTED WITH ZINC RICH PAINT. ALL ANCHOR BOLTS TO BE STAINLESS STEEL.

END BEARING DETAILS
SPANS B THRU I
SCALE



CAP PLAN

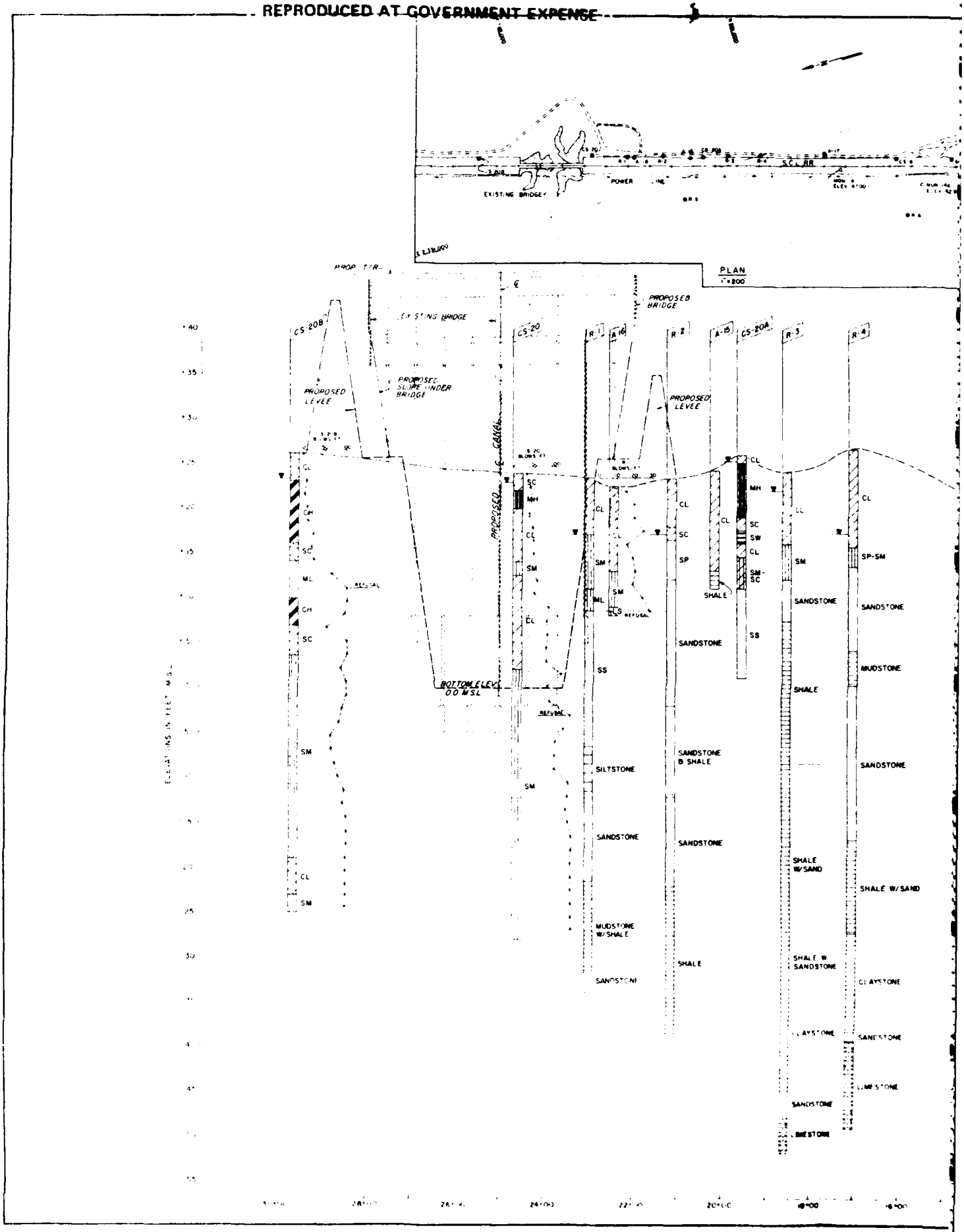


ELEVATION

END VIEW

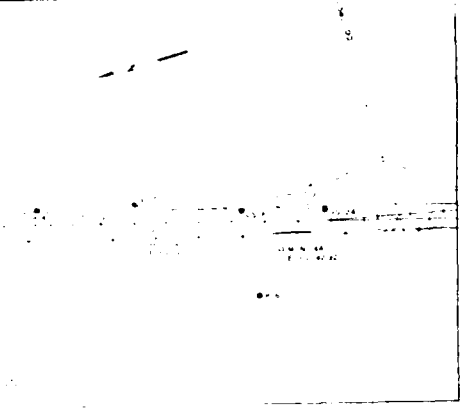
PIERS NO. 3 THRU 7
SCALE

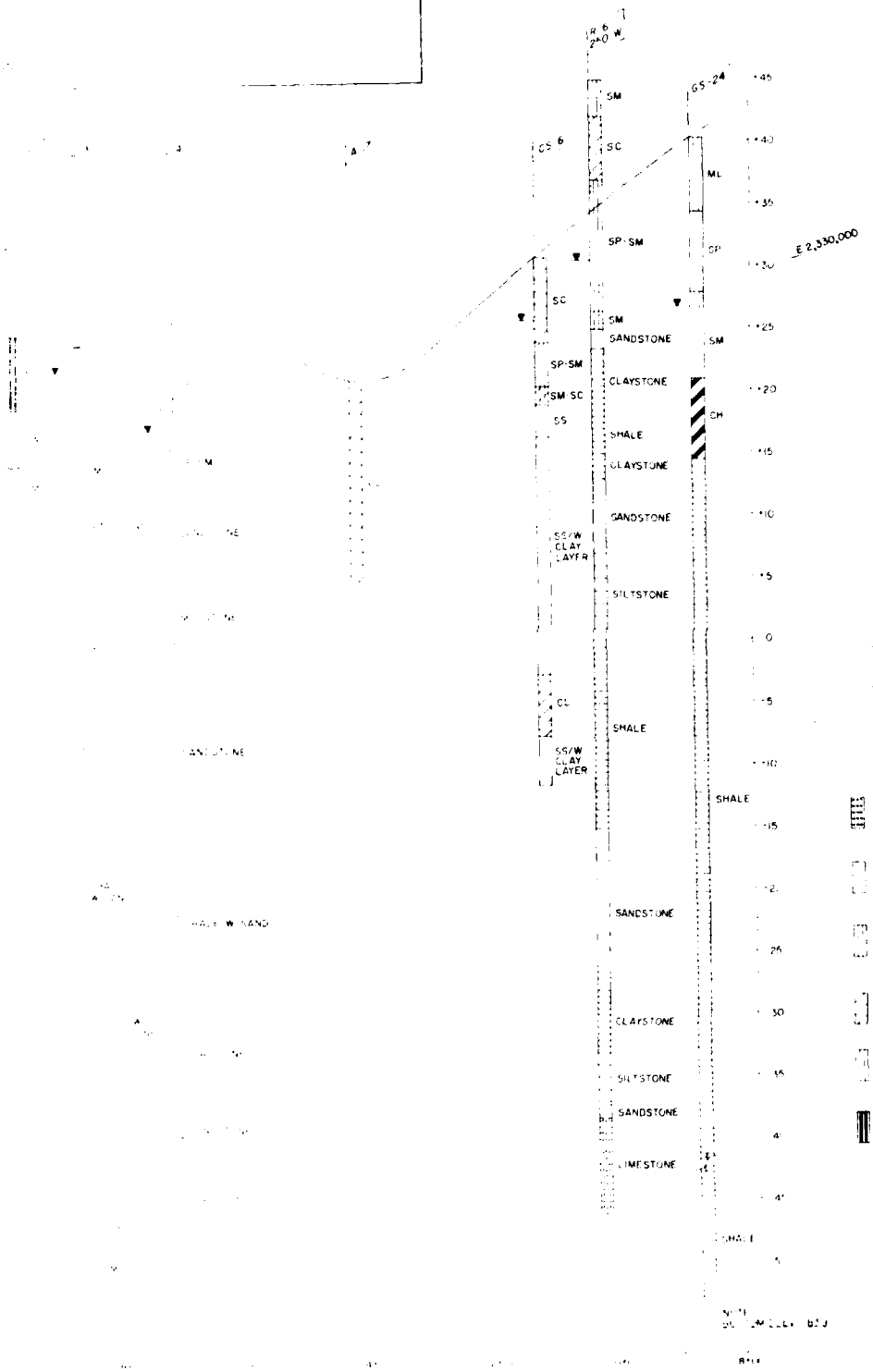
U.S. ARMY ENGINEER DISTRICT, CHARLESTON CORPS OF ENGINEERS CHARLESTON, SOUTH CAROLINA		
RELOCATION OF SEABOARD COAST LINE RAILROAD BRIDGE TYPICAL DECK SECTIONS CUBEN RIVER REVERSION PROJECT CAPE ROMAIN HARBOR, SANTEE RIVER, SOUTH CAROLINA		
SCALE AS SHOWN	DESIGN MEMORANDUM No. 8	SHEET A
DATE		FILE NO.



REVISIONS

SYMBOL	DESCRIPTION	BY



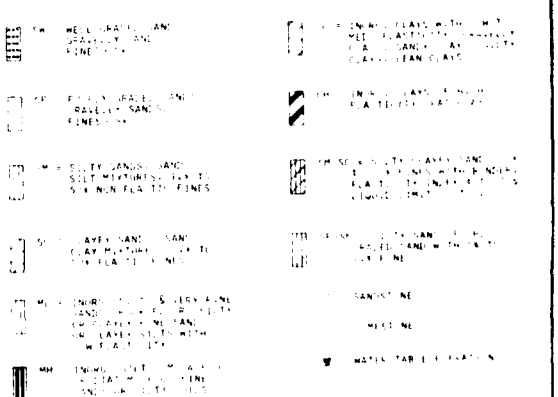


PROPOSED BORROW AREA
1"=200'

NOTES

1. SOIL CLASSIFICATIONS ARE BASED ON THE UNIFIED SOIL CLASSIFICATION SYSTEM AND ARE VISUAL FIELD CLASSIFICATIONS EXCEPT WHERE LABORATORY TESTED SAMPLES SHOWN ON TEST DATA SUMMARY SHEETS.
2. DETAILED INFORMATION FOR EACH HOLE MAY BE FOUND IN APPENDIX D.
3. WATER LEVELS IN RIVER HOLES ARE AVERAGE WHERE NOT RECORDED.
4. PIEZOMETER [illegible] WAS DESTROYED DECEMBER 1974 (GS 2).
5. WATER UNDER ARTESIAN HEAD FLOWS FROM B-3.

LEGEND



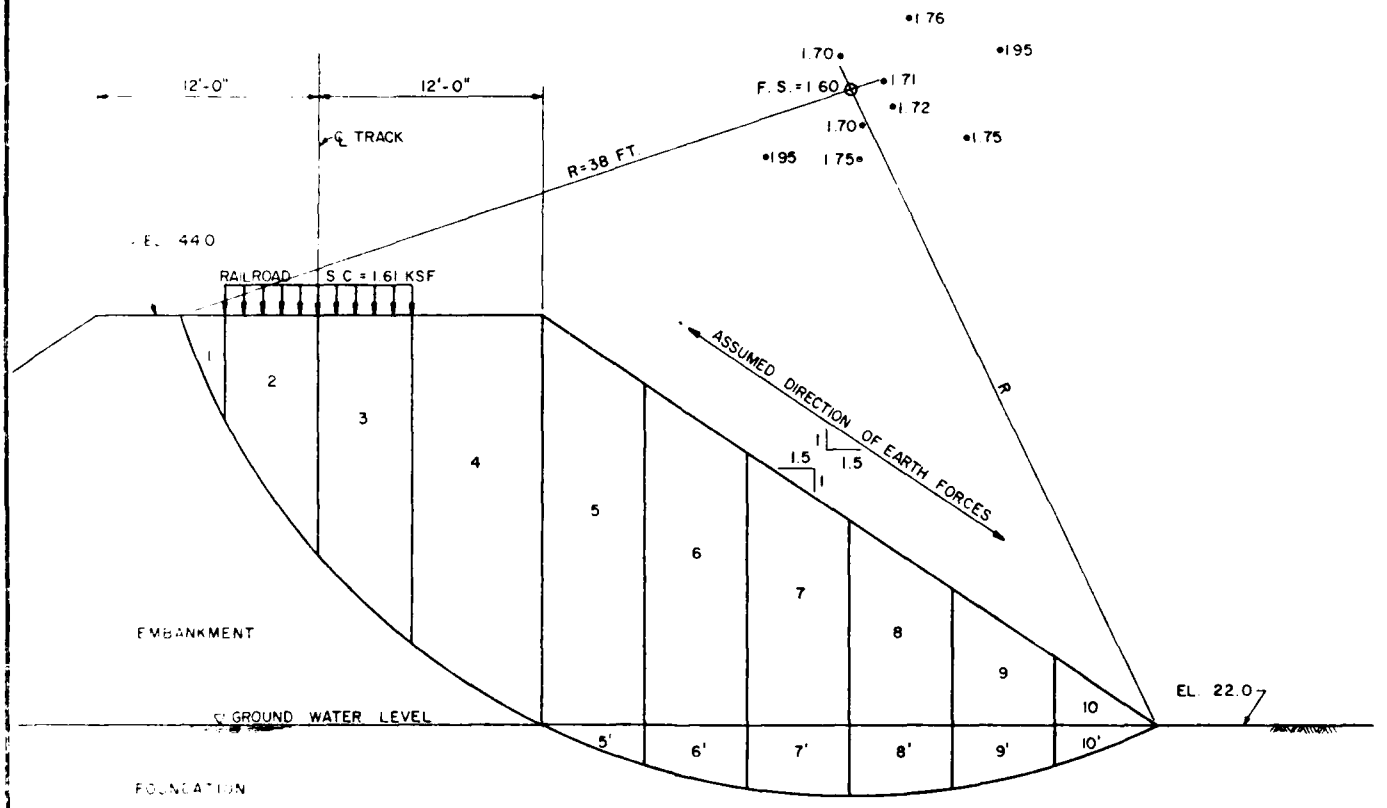
U. S. ARMY ENGINEER DISTRICT, CHARLESTON CORPS OF ENGINEERS CHARLESTON, SOUTH CAROLINA	
RELOCATION OF SEABOARD COAST LINE RAILROAD BRIDGE	
GEOLOGIC SECTION	
COOPER RIVER REDIVERSION PROJECT ABE M[illegible] AND SANTEE RIVER, SOUTH CAROLINA	
SCALE AS SHOWN	DESIGN MEMORANDUM NO. 8
DATE [illegible]	PLATE 7

SLIDING SURFACE IN	SLICE	HORIZONTAL WIDTH (FEET)	SLICE HEIGHT (FEET)			AREA OF SLICE (SQ. FT.)	WEIGHT (KIPS)			BASE LENGTH OF SLICE ΔL (FEET)	$c\Delta L$ (KIPS)	$\frac{c\Delta L}{F.S.}$ (KIPS)	ϕ_D (DEG)
			LEFT SIDE	RIGHT SIDE	AVERAGE		MOIST	SUBMERGED	TOTAL				
EMBANKMENT	1	2 3	0	5 5	2 8	6 3	0 8	—	0 8	5 9	5.4	3.4	12.2
	2	5 0	5 5	12 7	9 1	45 5	13 6*	—	13 6	8 8	8.1	5.1	
	3	5 0	12 7	17 5	15 1	75.5	17.2*	—	17.2	7.0	6.4	4.0	
	4	7 0	17 5	22 0	19 8	138.6	16.7	—	16.7	8 3	7.6	4.8	
FOUNDATION	5	5 5	22 0	18 3	20 2	111.1	13.4	—	13.7	5.9	3.0	1.9	2 2
	5'	5 5	0	2 2	1 1	6 1	—	0 3					
	6	5 5	18 3	14 7	16 5	90.7	11.0	—	11.8	5.6	2.8	1.7	
	6'	5 5	2 2	3 4	2 8	15 4	—	0.8					
	7	5 5	14 7	11 0	12 9	70 9	8.6	—	9.7	5.5	2.8	1.7	
	7'	5 5	3 4	3 8	3 6	19.8	—	1.1					
	8	5 5	11 0	7 3	9 2	50.6	6 1	—	7.2	5.5	2.8	1 7	
	8'	5 5	3 8	3 5	3 7	20.3	—	1.1					
	9	5 5	7 3	3 7	5 5	30 2	3.7	—	4.5	5.6	2.8	1.7	
	9'	5 5	3 5	2 2	2 9	15 9	—	0.8					
	10	5 5	3 7	0	1.9	10.4	1.2	—	1.5	6.0	3.0	1.9	
	10'	5 5	2 2	0	1.1	6.1	—	0.3					

FOR F S = 1 60

* INCLUDES SURCHARGE

MATERIAL	ADOPTED DESIGN Q STRENG	
	ϕ DEG	TAN ϕ
EMBANKMENT	19 5	0 354
FOUNDATION	3 5	0 061

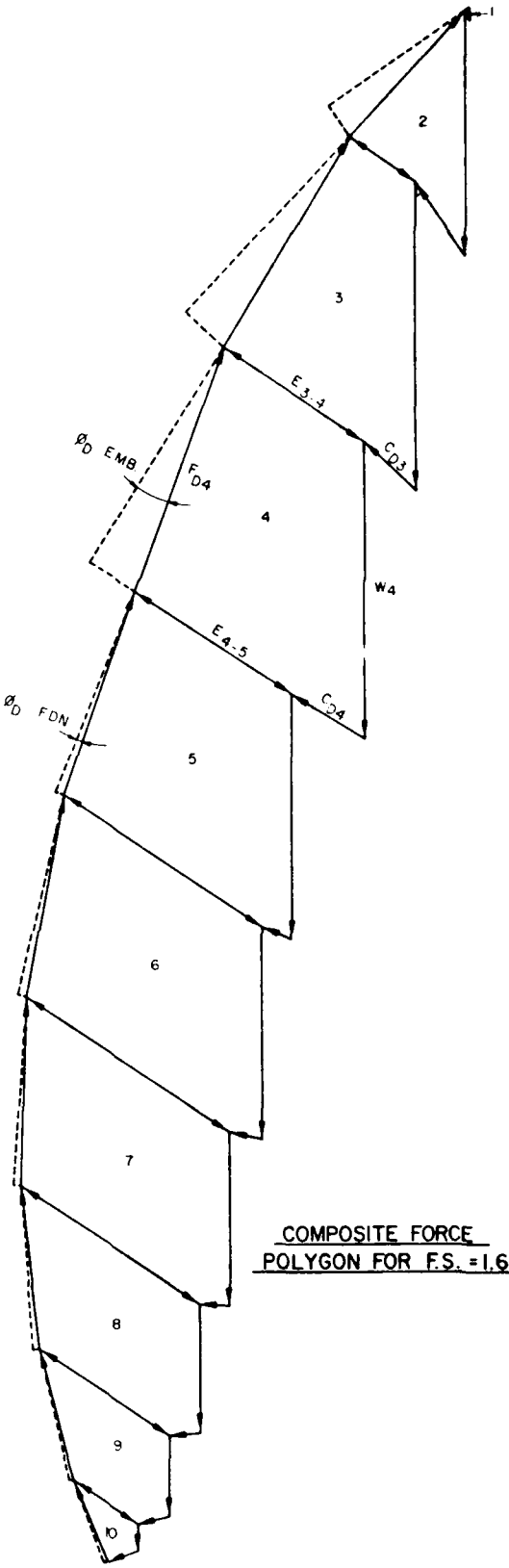


EMBANKMENT SECTION

SCALE

5 0 5 10 FT

ADOPTED DESIGN DATA					
MATERIAL	Q STRENGTH			UNIT WT LB / CU. FT	
	Ø DEG	TAN Ø	COHESION KIPS / SQ. FT.	γ_M	γ'
EMBANKMENT	19 5	0 354	0.92	121	—
FOUNDATION	3 5	0 061	0 50	—	54

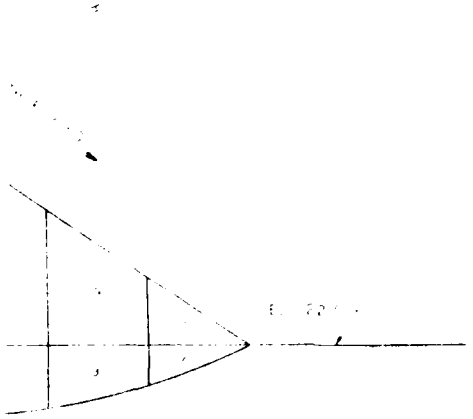


SCALE

5 0 5 10 KIPS

NOTE: FOR SLICE 1, IT WAS ASSUMED THAT THE DEVELOPED SHEAR RESISTANCE ON THE BASE OF THE SLICE CANNOT BE GREATER THAN THAT REQUIRED TO CLOSE THE FORCE POLYGON

COMPOSITE FORCE POLYGON FOR F.S. = 1.60



DETOUR EMBANKMENT
STABILITY ANALYSIS

END OF CONSTRUCTION CONDITION

MODIFIED SWEDISH METHOD
FINITE SLICE PROCEDURE

DESIGN MEMORANDUM NO. 8

RELOCATION OF
SEABOARD COAST LINE RAILROAD BRIDGE

COOPER RIVER REDIVERSION PROJECT
LAKE MOULTRIE AND SANTEE RIVER, SOUTH CAROLINA

FILE NO 10042 PLATE 8

ADOPTED DESIGN DATA

MATERIAL	SHEAR STRENGTH		UNIT WT. (LB/CU FT)		
	Ø DEG	COHESION KIPS/SQ FT	γ_M	γ_{SAT}	γ'
EMBANKMENT	14.5	0.96	121	130	67
FOUNDATION	13.0	0.40	—	—	54

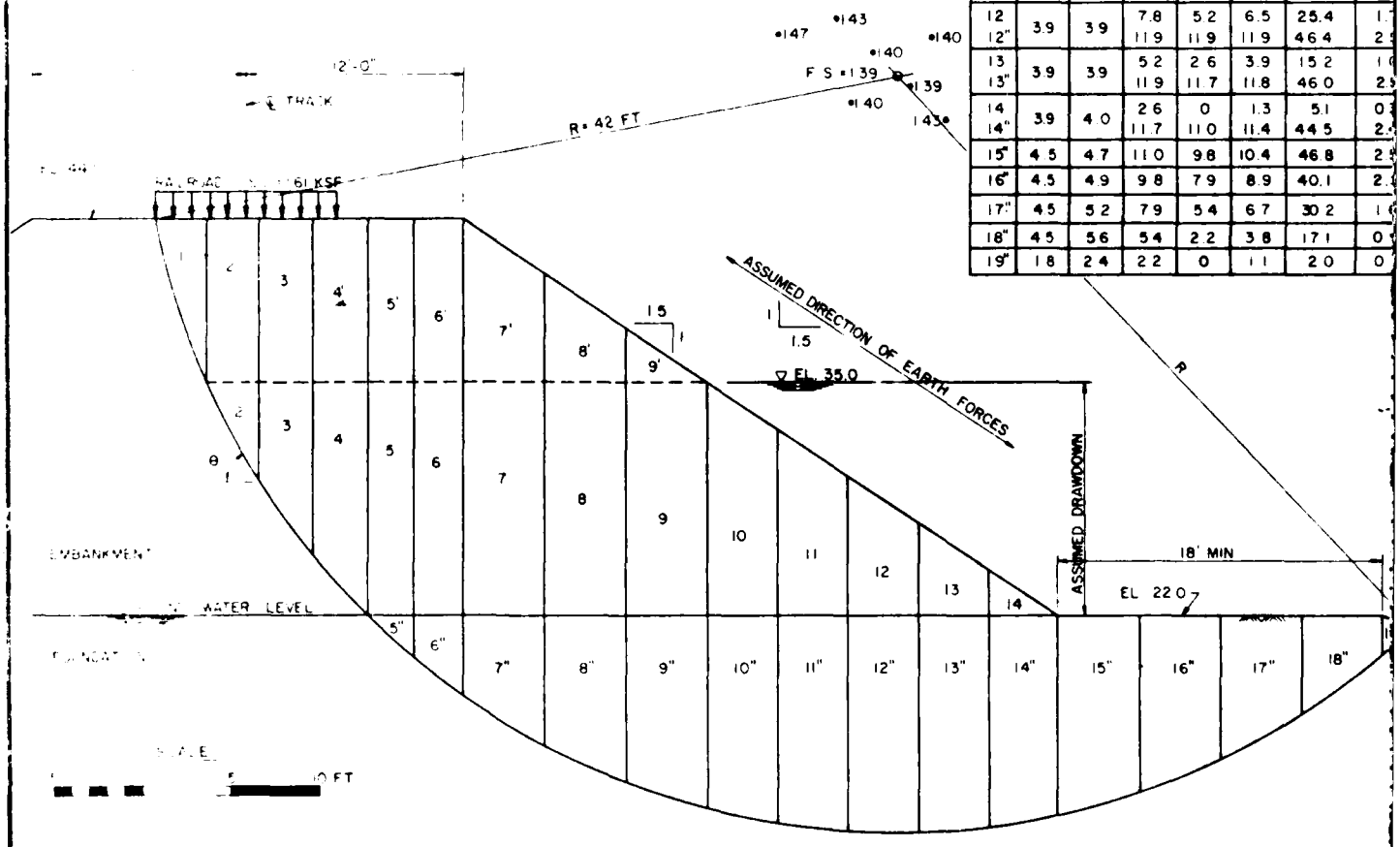
COMPUTATION OF FACTOR OF SAFETY

SLICE	N_ϕ	TAN Ø	N_D TAN Ø	ΔL FT.	cΔL KIPS	W KIPS	θ°	SIN θ	W SIN θ KIPS
1	3.1			9.5		6.0	72.5	.954	5.7
2	6.1			6.2		8.9	62.0	.883	7.9
3	7.6			5.1		11.1	54.0	.809	9.0
4	6.0			4.5		9.8	47.8	.741	7.3
2', 4	22.8	2.59	5.9	25.3	24.3	—	—	—	29.9
5	4.3			3.5		7.4	41.6	.664	4.9
6	4.4			3.4		8.0	37.0	.602	4.8
7	7.9			5.3		13.1	31.4	.521	6.8
8	7.4			5.0		12.1	24.6	.416	5.0
9	5.1			4.7		10.8	17.4	.299	3.2
10	5.5			4.0		8.2	11.5	.199	1.6
11	5.3			3.9		7.1	6.2	.108	0.8
12	5.2			3.9		5.8	0.9	.016	0.1
13	4.7			3.9		4.5	-4.1	.071	-0.3
14	4.2			4.0		3.1	-9.5	-.165	-0.5
15	4.6			4.7		2.5	-15.8	-.272	-0.7
16	5.2			4.9		2.2	-22.4	-.381	-0.8
17	5.9			5.2		1.6	-28.8	-.482	-0.8
18	8.4			8.0		1.0	-37.7	-.612	-0.6
Σ 1-9	79.8	2.31	18.4	64.4	25.8	—	—	—	23.5
Σ 10-19	—	—	24.3	—	50.1	—	—	—	53.4

$$F.S. = \frac{24.3 + 50.1}{53.4} = 1.39$$

MEASUREMENTS AND WEIGH

SLICE	HORIZONTAL WIDTH (FT)	BASE LENGTH OF SLICE ΔL (FT)	SLICE HEIGHT (FT)			AREA OF SLICE (SQ FT)	SUBMERGED
			LEFT SIDE	RIGHT SIDE	AVERAGE		
1'	2.8	9.5	0	9.0	4.5	12.6	
2'	2.9	6.2	9.0	9.0	9.0	26.1	
2			0	5.5	2.8	8.1	0.8
3'	3.0	5.1	9.0	9.0	9.0	27.0	
3			5.5	9.6	7.6	22.8	1.5
4'	3.0	4.5	9.0	9.0	9.0	27.0	
4			9.6	13.0	11.3	33.9	2.3
5'	2.6	3.5	9.0	9.0	9.0	23.4	
5			13.0	13.0	13.0	33.8	2.3
5"			0	2.3	1.2	3.1	0.2
6	2.7	3.4	9.0	9.0	9.0	24.3	
6			13.0	13.0	13.0	35.1	2.4
6"			2.3	4.4	3.4	9.2	0.5
7'	4.5	5.3	9.0	6.0	7.5	33.8	
7			13.0	13.0	13.0	58.5	3.9
7"			4.4	7.2	5.8	26.1	1.4
8'	4.5	5.0	6.0	3.0	4.5	20.3	
8			13.0	13.0	13.0	58.5	3.9
8"			7.2	9.2	8.2	36.9	2.0
9'	4.5	4.7	3.0	0	1.5	6.8	
9			13.0	13.0	13.0	58.5	3.9
9"			9.2	10.6	9.9	44.6	2.4
10	3.9	4.0	13.0	10.4	11.7	45.6	3.0
10"			10.6	11.5	11.1	43.3	2.3
11	3.9	3.9	10.4	7.8	9.1	35.5	2.4
11"			11.5	11.9	11.7	45.6	2.5
12	3.9	3.9	7.8	5.2	6.5	25.4	1.7
12"			11.9	11.9	11.9	46.4	2.5
13	3.9	3.9	5.2	2.6	3.9	15.2	1.0
13"			11.9	11.7	11.8	46.0	2.5
14	3.9	4.0	2.6	0	1.3	5.1	0.3
14"			11.7	11.0	11.4	44.5	2.4
15"	4.5	4.7	11.0	9.8	10.4	46.8	2.5
16"	4.5	4.9	9.8	7.9	8.9	40.1	2.2
17"	4.5	5.2	7.9	5.4	6.7	30.2	1.6
18"	4.5	5.6	5.4	2.2	3.8	17.1	0.9
19"	1.8	2.4	2.2	0	1.1	2.0	0

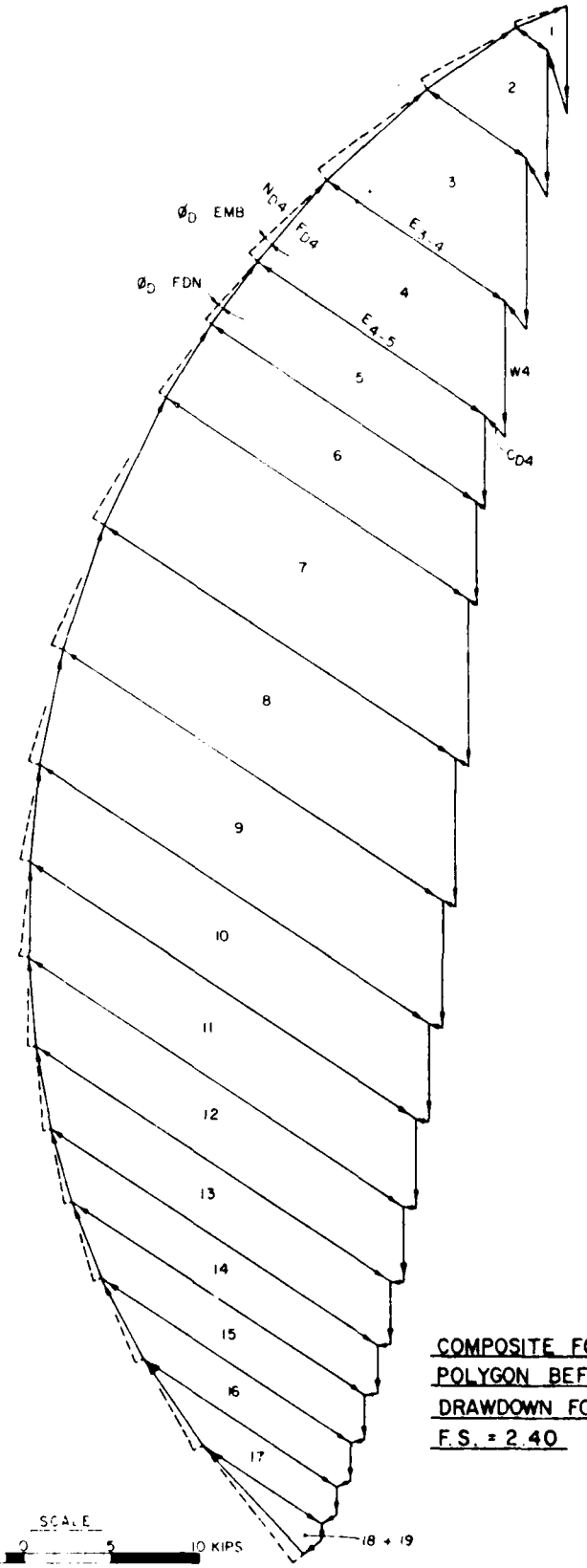


EMBANKMENT SECTION

MEASUREMENTS AND WEIGHTS

				SLICE HEIGHT (FT)				WEIGHT (KIPS)			
			BASE LENGTH OF SLICE (FT)	LEFT SIDE	RIGHT SIDE	AVERAGE	AREA OF SLICE (SQ FT)	SUBMERGED	MOIST OR SATURATED	TOTAL WT BEFORE DRAWDOWN	TOTAL WT AFTER DRAWDOWN
					9	4	26	—	60*	60	60
			62	90	90	90	261	—	78*	83	8.9
				0	55	28	81	05	11		
			51	90	90	90	270	—	81*	96	11 1
				55	96	76	228	15	30		
			46	90	90	90	270	—	54*	77	9.8
				33	130	113	339	23	44		
			55	90	90	90	234	—	28	53	7.4
				30	130	30	338	23	44		
				0	23	12	31	02	—		
			34	30	90	30	243	—	23	58	80
				130	130	30	351	24	46		
				23	44	34	92	05	—		
			61	90	60	75	338	—	41	94	13 1
				130	130	130	585	39	76		
				44	72	58	261	14	—		
			55	60	30	45	223	—	25	84	12 1
				30	30	30	585	39	76		
				72	96	84	369	20	—		
		43	47	30	0	5	68	—	98	71	98
				30	130	130	585	39	76		
				92	26	99	446	24	—		
		39	40	130	104	117	456	31	59	54	82
				106	115	111	433	23	—		
		39	39	104	78	91	355	24	46	49	71
				115	119	117	456	25	—		
	12	39	39	78	52	65	254	17	33	42	58
				119	119	119	464	25	—		
		39	39	52	26	39	152	10	20	35	45
				119	117	118	460	25	—		
		40	40	26	0	13	51	03	07	27	31
				117	110	114	445	24	—		
		45	47	110	98	104	468	25	—	25	25
		45	49	98	79	89	401	22	—	22	22
		45	52	79	54	67	302	16	—	16	16
		47	56	54	22	38	171	09	—	09	09
			24	22	0	11	20	01	—	01	01

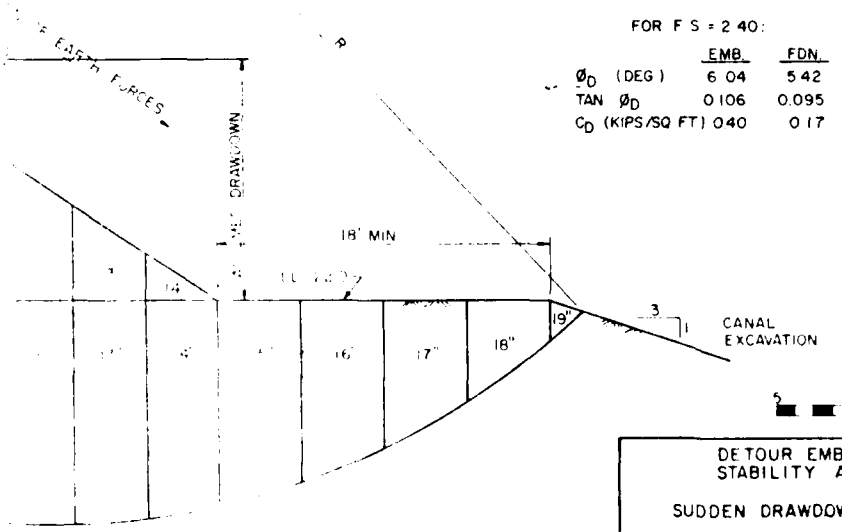
* INCLUDES SURCHARGE



COMPOSITE FORCE POLYGON BEFORE DRAWDOWN FOR F.S. = 2.40

FOR F S = 2.40:

	EMB.	FDN.
ϕ_D (DEG)	6 04	5 42
TAN ϕ_D	0.106	0.095
C_D (KIPS/SQ FT)	040	0 17



SCALE
5 0 5 10 KIPS

DETOUR EMBANKMENT
STABILITY ANALYSIS

SUDDEN DRAWDOWN CONDITION

MODIFIED SWEDISH METHOD
FINITE SLICE PROCEDURE

DESIGN MEMORANDUM NO. 8

RELOCATION OF
SEABOARD COAST LINE RAILROAD BRIDGE

COOPER RIVER REDIVERSION PROJECT
LAKE MOULTRIE AND SANTEE RIVER, SOUTH CAROLINA

FILE NO 10042 PLATE 9

APPENDIX NO. "A"

ATTORNEY'S JUSTIFICATION REPORT

JUSTIFICATION REPORT

Relocation of
Seaboard Coast Line Railroad Bridge
Cooper River Rediversion Project
South Carolina

Pursuant to the provisions of Engineer Regulations 1180-1-1, Section 73, Justification Report is herewith submitted relative to the proposed relocation of certain facilities owned by the Seaboard Coast Line Railroad Company made necessary by reason of the construction and operation of the Cooper River Rediversion Project, South Carolina.

1. FACTS:

a. The Seaboard Coast Line Railroad Company, a Virginia Corporation, with corporate headquarters in Richmond, Virginia, and principal offices in Jacksonville, Florida, maintains and operates a railroad for the transportation of freight and passengers along the eastern seaboard of the United States. A portion of the Company's railroad line will be affected by the proposed Cooper River Rediversion Project. The affected portion of the railroad line is located in Berkeley County, South Carolina, and further identified by proximity to Seaboard Coast Line Mile Post A-347.9. Title to the right-of-way is vested in the Seaboard Coast Line Railroad Company.

b. The main line of the Seaboard Coast Line Railroad between Virginia and Florida crosses the proposed canal about 1-1/2 miles north of St. Stephen, South Carolina. The railroad at this location constitutes the Company's main north-south route and is indispensable to rail service. The necessity for keeping this track in service at all times is apparent since there is no reasonable substitute route. Proposed canal excavation through the existing single-track embankment and existing railroad bridge will necessitate construction of a new permanent bridge and construction of a temporary detour track in order to maintain traffic while the permanent bridge is being built. The existing track grade, which has been constructed on fill material and bridges at a height of approximately twenty-four feet above the Santee River Swamp, will provide adequate clearance above the tailrace canal.

2. OWNERSHIP:

The Seaboard Coast Line Railroad Company owns fee simple determinable title, subject to defeasance if not used to operate a railroad, to the right-of-way over the area affected by canal construction. The estate was acquired under authority of a Special Act of the South Carolina Legislature (Act 1851,

No 4069). The Railroad was constructed through this site between 1853 and 1856 and has been in continuous operation since that time. Original ownership of the estate was acquired by the North-Eastern Railroad Company, a corporation created by the General Assembly of South Carolina on 16 December 1851, whose assets were acquired by the Atlantic Coast Line Railroad in 1898. On 1 July 1967 the Atlantic Coast Line was merged into the Seaboard Coast Line Railroad Company.

3. CONTROL:

a. The South Carolina Public Service Commission has general supervision of all railroads operated within that State. (S.C. Code Sec. 58-1031). The law authorizes any railroad company operating under authority of the laws of the State of South Carolina to relocate its lines and make other changes that are necessary for the purpose of the better and more expeditious handling of the public business. (S.C. Code Sec. 58-965).

b. In view of the foregoing legislative authority in South Carolina, and the fact that no interruption or discontinuance of service will result from the proposed relocation, approval of the South Carolina Public Service Commission is not required.

4. COMPENSABLE INTEREST:

Interest in real estate held by public corporations, whether it be in fee, by easement, or prescription, are all such interest in land which cannot be extinguished or subrogated by the United States without payment of just compensation therefor. (U.S. vs. Gettysburg, 160 U.S. 668, 40 L. Ed. 576; Mo. K. & T. RR Co. vs. Rockwall Co., 117 Texas 34, 297 S. W. 206; U. S. vs. Wheeler Township, CCA, Minn. 1933, 66 F. 2d 977).

5. LEGAL LIABILITY OF THE GOVERNMENT:

The liability of the Government is limited to providing the minimum replacement facilities as are necessary to provide equal service and utility as presently enjoyed and without consideration for betterments. Betterments can only be considered where same are essential to provide equal service and utility. The question as to whether betterments are necessary to provide equal service and utility is a question for strict engineering determination. The modification and relocation of this line must be the most economical in providing adequate transportation facilities.

6. GENERAL SYNOPSIS OF THE LAW INVOLVED:

a. There is no question but that the United States Government in its sovereign capacity has authority to take any property that is needed for public use, with the sole restriction as provided in the 5th Amendment of the United States Constitution, which in effect provides that private property shall not be taken for public use without payment of "just compensation" therefor. Lands previously devoted to public use, may, under the power of eminent domain, be taken for another public use when the latter use is more beneficial to the general public and is not destructive of the rights of the public under the first taking. (U. S. vs. Gettysburg, 160 U. S. 668, 40 L. Ed. 576; Jefferson County vs. Birmingham, 217 Ala. 268, 115 So. 422; Northern Pac. R. Co. vs. Duluth, 153 Minn. 122, 189 N. W. 937; State Highway Comm. vs. Elizabeth, 102 N. J. Eq. 221, 140 Atl. 335; In re, New York City, 219 App. Div. 478, 220 N. Y. S. 298; Hudson Riv. Regulating Dist. vs. Fonda, J. & C. R. Co., 127 Misc. 866, 217 N. Y. S. 781; Gund Realty Co. vs. Cleveland, 26 Ohio App. 590, 160 N. E. 101; Williamson County vs. Franklin & Spring Hill Tpk. Co., 143 Tenn. 628, 228 S. W. 714; Missouri, K. & T. R. Co. vs. Rockwall Co., 117 Tex. 34, 297 S. W. 206; Texas & N. O. R. Co. vs. Beaumont, (Tex. Civ. App.), 285 S. W. 944).

b. The Government is responsible for damages to "private property" which results from the exercise of its powers of eminent domain. Easements, as well as fee interests, are property rights within the protection of the 5th Amendment to the Constitution which prohibits the taking of private property for public use without payment of just compensation therefor. This principle of law is affirmed in the following leading cases:

(1) Under Constitutional provisions although a power company builds a dam pursuant to legislative authority, if it thereby floods private property, it must make compensation to those particularly injured thereby. (Edgefield County vs. Georgia-Carolina Power Co., 88 S. E. 801, 104 S. C. 311.)

(2) Where fee simple of land condemned was subject to an easement for road purposes, Government could not abrogate easement and pay for fee simple title alone, but was also liable to owner of the easement. (U. S. vs. Gossler, D. C. Or. 1945, 60 F. Supp. 971.)

(3) Where the property of an individual is taken or condemned for public use, the positive law, as well as justice and equity, require fair and reasonable compensation. (Raleigh, C. & S. Ry. vs. Mecklenburg Mfg. Co., 85 S. E. 390, 169 N. C. 156.)

(4) Where lands were condemned for water power project, the landowner is entitled to compensation for all lands taken, even though as to some of the lands the condemnor desired only an easement; for the right to use the land condemned is just as much a taking as if the land were actually used all of the time. (Wateree Power Co. vs. Rion Co., 102 S. E. 331, 113 S. C. 303.)

(5) The property of a public utility, although devoted to the public service and impressed with a public interest, is still private property; and neither the corpus of that property, nor the use thereof constitutionally can be taken for a compulsory price which falls below the measure of just compensation. (United Rep. and Electric Co. of Baltimore vs. West, 280 U. S. 234, 74 L. Ed. 390).

c. The question arises in connection with property rights for which "just compensation" must be paid relative to the extinguishment thereof as to what is "just compensation". The term "just compensation", as used in the 5th Amendment of the Constitution, is flexible enough to permit the application of many tests in connection with determining its equivalent. A land interest covering a small portion of a Railroad company right-of-way does not in itself have an inherent market value. Therefore, the usual methods of determining value such as cost of construction, age, depreciation, and what a willing buyer would give to a willing seller for the purchase thereof cannot be used as a yardstick in determining value. The cases hereinafter referred to enumerate the problems involved and provide the method for determining "just compensation".

(1) Constitutional requirements of "just compensation" for private property taken for public use means that the owner must be made whole for what is taken from him ... where ordinary measure of loss or degrees of market value cannot be applied, whatever is necessary to be considered to determine equivalent for appropriation of private property is germaine to the question of compensation. (U. S. vs. Wheeler Tp., 66 F. 2d 977).

(2) "Just compensation" within constitutional prohibition against the taking of private property for public use without "just compensation" means substantially that the owner shall be in as good position pecuniarily as he would have been if his property had not been taken. (Walker vs. U. S., 64 F. Supp. 135).

(3) "Just compensation" means full and perfect equivalent in money of property taken ... and owner is to be put in as good condition pecuniarily as he would have occupied if his property had not been taken. (General Motors Corp. v. U. S., 140 F. 2d 873).

(4) "Value" as used in the statute concerning the taking of land under eminent domain, is a relative term, dependent on its meaning upon the circumstances in which it is used. (State Hwy. Board vs. Bridges, 3 S. E. 2d. Series 907, 60 Ga. App. 240).

(5) In a proceeding to condemn the property of a railroad company for the purpose of extending a street under its tracks, such company is entitled to compensation for the cost of a bridge to carry its trains over the street. (Cincinnati, etc., R. Co., vs. Troy, 68 Ch. St. 510, N. E. 1051).

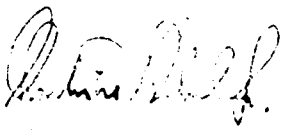
(6) A railroad was entitled to compensation for the cost of building a retaining wall necessitated by the extension by condemnation proceedings of a street under its tracks, although the work was ordered by the Railroad Commission and the railroad might abandon the tracks. (New York, etc. R. Co. vs. New Haven, 81 Conn 381, 71 A 780).

d. Summary.

(1) The Government is legally liable unto the Railroad Company for damages that may be occasioned by reason of the Government's interference with property rights of said Company.

(2) The test as to value is novel to the extent that ordinary methods of determining "just compensation" cannot be applied. A land interest covering an isolated portion of a railroad company's right-of-way has no inherent market value in itself except as to its service in connection with the entire railroad company's right-of-way. However, to sever a railroad company's line by the taking of its right-of-way at any location without provision for relocation or readjustment could conceivably cost the railroad company millions of dollars in damages. Therefore, relocations and adjustments must be made where same are necessary in order that there be no interruption in rail services.

(3) The law contemplates that where private property is taken for public use, the owner shall be made whole. In other words, the Government shall pay the full and perfect equivalent of the property taken in order that he may be put in as good condition pecuniarily as he was prior to the taking. In the instant cases, relocations are involved. The Government's pecuniary liability is the actual cost to the Railroad Company for relocating its line, in the most economical manner, necessary to provide the same services as presently enjoyed. The payment of said sum will place the Railroad Company in as good position as it now occupies and will extinguish the Government's obligation in connection therewith.



25 March 1976

CHARLES M. DEBELE, JR.
Attorney
Real Estate Division

APPENDIX NO. "B"

DESIGN COMPUTATIONS

RALPH WHITEHEAD & ASSOCS.
CONSULTING ENGINEERS
1936 E. SEVENTH STREET
CHARLOTTE, N. C.

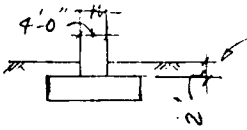
BY RA DATE 2-19-76 SHEET NO. 1 OF
CKD. BY ACS DATE 2-19-76 JOB NO. 7-1297
SUBJECT SCL Bridge Over Cooper R.V. Rediversion Canal

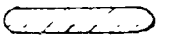
(a)

Hydraulic head loss caused by bridge piers

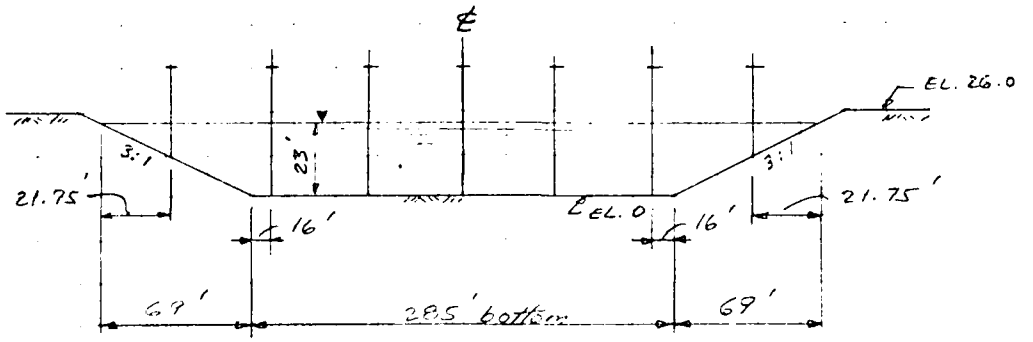
Ref.: Hydraulics of Bridge Waterways, FHWA

Bridge: 8 main spans @ 63'-3" (Symmet. about ℄ canal)

Piers ~ 


Pier shape

Normal Flow: Q = 24,500 cfs
depth of water = 35.0'



$A_{n2} = 23 \times (285 + 69) = 8192\ ft^2$

$A_{piers} = 5(4 \times 23) + 2(7.25 \times 4.0) = 518\ ft^2$

$J = 518/8192 = 0.064$: From Fig 7, $\Delta k = 0.12 = \Delta k_p$

For channel flow, $M = 1$
(Fig. 5), $\alpha_1 = 1$ $\alpha_2 = 1$
(Fig. 6) $k_b = 0$

Fig. 6 Fig. 7
$k^* = k_b + \Delta k_p$
$\therefore \Delta k_p = 0.12 = k^*$

$V_{n2} = \frac{24,500}{8192} = 3.0$ FPS

From equation (9.)
approximate backwater $= 0.12\,(1.0)\,\frac{(3)^2}{69.4} = 0.017$ ft
kinetic energy difference will be insignificant

$\therefore$ Head loss = backwater = 0.017' < .05' max
and proposed bridge is acceptable

RW. FORM 3

RALPH WHITEHEAD & ASSOCS.
CONSULTING ENGINEERS
1936 E. SEVENTH STREET
CHARLOTTE, N. C.

BY JEF DATE FEB 19, '76 SHEET NO. 2 OF
CKD. BY ACS DATE March 3, 76 JOB NO. C-1297
SUBJECT SCOUR P.C. ABUTMENT
COOPER RIVER REDIVERSION CANAL

SCOUR AT BRIDGE PIERS

REF. FOUNDATION ENGINEERING 1971 INTEXT EDUCATIONAL PUB.
ALFREDS R. JUMINS
PG 704

$V_s = m d^{0.64}$

V_s = CRITICAL MEAN VELOCITY (FT/SEC) FOR CRITICAL SECTION OF THE FLOW CHANNEL

m = 0.90 (FOR COARSE, HIGH, CANAL ETC.

d = DEPTH OF WATER (ft)

SAVE FOR V_s

$V_{s_1} = 0.90 (23)^{0.64}$
$= 0.90 \times 7.44$
$= 6.7$ '/SEC

$V_{s_2} = 0.90 (10)^{0.64}$
$= 0.90 \times 4.37$
$= 3.9$ '/SEC

V_B = BOTTOM VELOCITY = $0.75 V_s$

$V_{B_1} = 0.75 (6.7) = 5.03$ '/SEC > 1.00 '/SEC FOR SAND
$V_{B_2} = 0.75 (3.9) = 2.93$ '/SEC > 1.00 '/SEC " "

SCOUR WILL OCCUR - CHECK DEPTH OF SCOUR.
(NEXT SHEET)

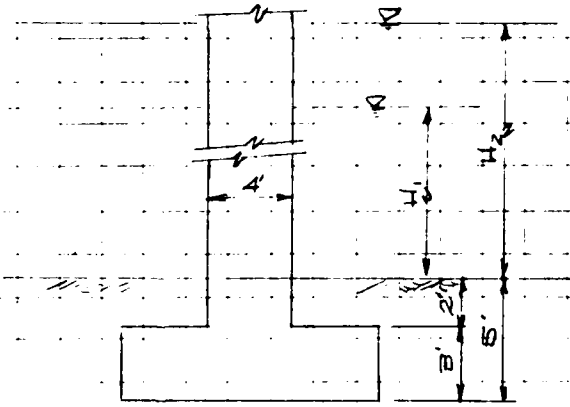
RW. FORM 3

RALPH WHITEHEAD & ASSOCS.
CONSULTING ENGINEERS
1936 E. SEVENTH STREET
CHARLOTTE, N. C.

BY JEF DATE FEB. 19, '76 SHEET NO. 3 OF
CKD. BY ACS DATE March 3, 76 JOB NO. C-1297
SUBJECT SCLRR BRIDGE OVER COOPER RIVER REDIVERSION CANAL

SCOUR AT BRIDGE PIERS

REF: FOUNDATION ENGINEERING 1971 INTEXT EDUCATIONAL PUB.
ALFREDS R. JUMIKIS
PGS 707 – 716



DEPTH OF SCOUR (IN METERS)
S_{MAX} = DEPTH OF SCOUR
C_1 ⇒ NOSE FORM COEFFICIENT
C_2 ⇒ FUNCTION OF SHAFT DESIGN WIDTH (B_1) AND FLOW VELOCITY (V_0)
C_3 ⇒ FUNCTION OF FLOW DEPTH (H) AND SHAFT DESIGN WIDTH (B_1)
AV. VEL. = 3.0 ft/SEC
= 0.91 M/SEC

ALL UNITS CONVERTED TO METRIC EQUIVALENT:

C_1 = 0.87 (FROM TABLE 21-4 PG 710)
C_2 ∴ $V_0^2/B_1 = (0.91)^2/1.22 = 0.68$
∴ C_2 = 0.77 (FROM FIG 21-E PG 714)
C_3: (FOR H_1 = 10') 3.05m / 1.22m = 2.50
∴ C_3 = 1.25 (FROM FIG 21-9 PG 714)
C_3: (FOR H_2 = 23') 7.01m / 1.22m = 5.75
∴ C_3 = 1.05 (FROM FIG 21-9 PG 714)

FOR H = 10' (3.05 m) d = PARTICLE SIZE IN METERS
= C

$S_{MAX} = C_1 C_2 C_3 (V_0)^2 = f(d)$
= 0.87 (0.77)(1.25)(0.91)²
= 0.69 m ⇒ 2.26' DEPTH

FOR H = 23' (7.01 m)
S_{MAX} = 0.87 (0.77)(1.05)(0.91²)
= 0.58 m ⇒ 1.90' DEPTH

O.K. JUST TO TOP OF FOOTING

RW. FORM 3

RALPH WHITEHEAD & ASSOCS.
CONSULTING ENGINEERS
1936 E. SEVENTH STREET
CHARLOTTE, N. C.

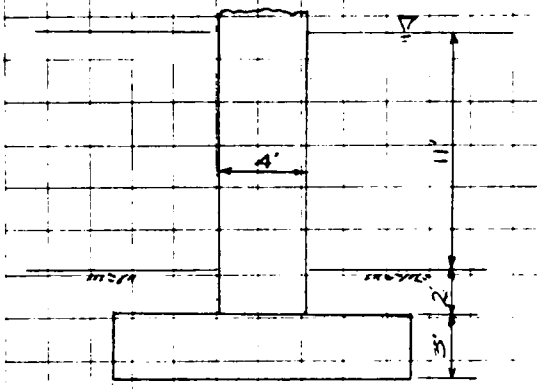
BY JEF DATE 4-1-76 SHEET NO. 4 OF
CKD. BY R.C.L. DATE 4/1/76 JOB NO. C-1297
SUBJECT SCLRR BRIDGE OVER COOPER RIVER REDN CANAL

SCOUR AROUND BRIDGE PIERS

FOUNDATION ENGINEERING
ALFRED R JUMKINS

INITIAL CONDITIONS: WATER @ EL. 11.0

V_o = 6 fps = 1.83 M/sec



DEPTH OF SCOUR (METRES)

S_{MAX} = DEPTH OF SCOUR

C_1 = NOSE FORM COEFFICIENT

C_2 = FUNCTION OF SHAFT DESIGN WIDTH (B) AND FLOW VELOCITY (V_o)

C_3 = FUNCTION OF FLOW DEPTH (H) AND SHAFT DESIGN WIDTH (B)

ALL UNITS ARE CONVERTED TO METRIC EQUIV

C_1 = 0.87 (TABLE PG 716)

C_2 = 0.65 (FIG 21-8 PG 714)

C_3 = 1.15 (FIG 21-9 PG 714)

$\frac{V_o^2}{B_1} = \frac{1.83^2}{1.22} = 2.75$

$\frac{H}{B_1} = \frac{3.35}{1.22} = 2.75$

ASSUME PARTICLE SIZE (d) = 0 METRES (CONSELVATIVE)

$S_{MAX} = C_1 C_2 C_3 V_o^2 - 30d^{*0}$

$= 0.87(0.65)(1.15)(1.83)^2$

= 2.18 METRES = 7.15' TOO MUCH

SET $S_{MAX} = 0$ SOLVE FOR d (PARTICLE SIZE)

$0 = 2.18 - 30d$

$30d = 2.18$ METRES

$d = 0.0727$ METERS

$\approx$ 3" STONE

∴ PLACE 3" STONE OR LARGER INSIDE PIER COFFERDAM

RW. FORM 3

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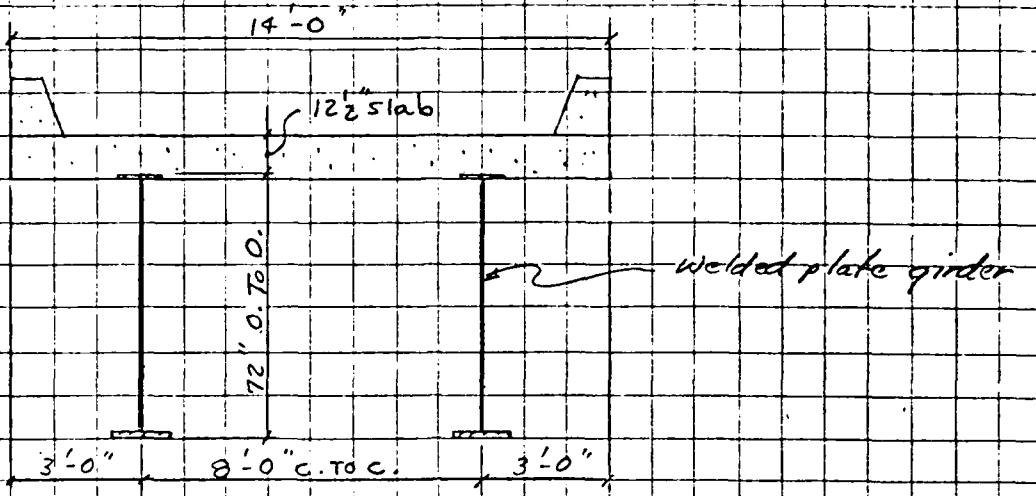
1936 E. SEVENTH STREET
CHARLOTTE, N. C.

BY RA DATE 2-2-76 SHEET NO. 5 OF
CKD. BY JEF DATE 2-20-76 JOB NO. C-1297
SUBJECT SCL Bridge Over Cooper Rv. Rediv. Canal

(b)

Structural Steel Spans



Steel: ASTM A588, composite construction
Allowable stresses based on A36 steel (S.C.L. standard practice.)

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CHARLOTTE, N. C.

BY RA DATE 2-2-76 SHEET NO. 6 CF
CKD. BY JEF DATE 2.2.76 JOB NO. C-1297
SUBJECT SCL Bridge over Cooper Rv. Redlv. Canal

Structural Steel Spans: End spans 41'-0", 43'-0" } 590' bridge
Main spans 8 @ 63'-3" }

63'-3" Span : 61'-6" c-c brgs.

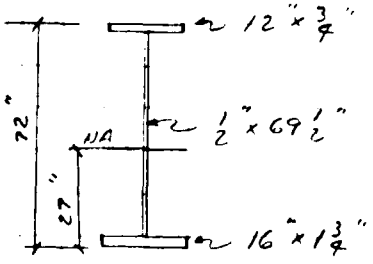
Dead Loads	on steel	on composite
Rails 200#/2	–	100#/FT.
Ballast + ties 120 × 1.25 × 6.0	–	900
Concrete = 7.0 × 1.10 × 150 =	1155#/FT	–
Curb = 1.33 × 1.0 × 150 =		200
Girder =	256	
Miscell. steel	45	
	1456#/FT	1200#/FT

$$\text{Impact} = 0.90\left[\frac{100}{8} + 40 - \frac{3(61.5)^2}{1600}\right] = 40.9\%$$

Midspan Moments

$$M_{DL\,(noncomp.)} = \frac{1}{8}(1.46)(61.5)^2 = 690^{k'}$$
$$M_{DL\,(comp.)} = \frac{1}{8}(1.20)(61.5)^2 = 567^{k'}$$
$$M_{LL} = 678.5(7.2)\left(\tfrac{1}{2}\right) = 2443^{k'}$$
$$M_I = 2443\,(.409) = 999^{k'}$$
$$3442^{k'}$$

Effective slab width = 7'-0" = 84"
slab t Use 13"



Steel section only.

	A	Y	AY
B.#.	28.0	.875	24.5
Web	39.75	36.50	1268
Top	9.0	71.625	645
	71.75 in²		1938 in³

$$\bar{Y} = \frac{1938}{71.75} = 27.0"$$

RW. FORM 3

RALPH WHITEHEAD & ASSOCS.
CONSULTING ENGINEERS
1936 E. SEVENTH STREET
CHARLOTTE, N. C.

BY RA DATE 2-2-76 SHEET NO. 7 OF
CKD. BY JCE DATE 2-20-76 JOB NO. C-1297
SUBJECT SCL Bridge
Cooper Rv. Redir. Channel

Steel Girder

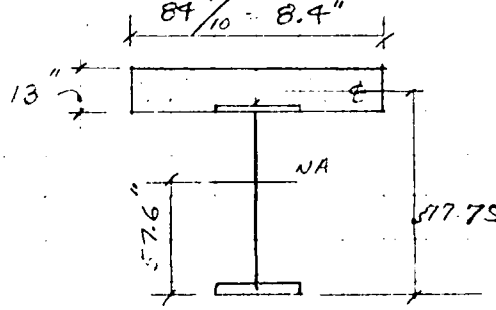
I: web $13988 + 39.75(7.5)^2 = 17127$
Both. Fl $28.0(26.125)^2 = 19110$
Top Fl $9.0(44.625)^2 = 17925$
$I_{steel} = 54,159 \text{ in}^4$

$S = I/c$ $S_{Top} = 1209 \text{ in}^3$ $S_{Both.} = 2005 \text{ in}^3$

stresses: $f_{Top} = \frac{690 \times 12}{1209} = 6.88 \text{ ksi}$

$f_{Both} = \frac{690 \times 12}{2005} = 4.13 \text{ ksi}$

Composite section ($n = 10$) ignore creep



$A_{conc} = 13 \times 8.4 = 109.2 \text{ in}^2$
$I_o = \frac{1}{12}(8.4)(13.0)^3 = 1538 \text{ in}^4$

	A	Y	AY
steel	71.75	27.0	1937
conc.	109.2	77.75	8490
	181		10427

$\bar{Y} = \frac{10427}{181} = 57.6"$

I:
steel $54,159 + 71.75(30.6)^2 = 121,342$
conc. $1538 + 109.2(20.15)^2 = 45,876$
$I_{comp.} = 167,218 \text{ in}^4$

$S_{Top} = 11,610 \text{ in}^3$ $S_{Both.} = 2,903 \text{ in}^3$

stresses: $f_{Top} = \frac{(3442 + 567)12}{11,610} = 4.14 \text{ ksi}$

$f_{Both} = \frac{(3442 + 567)12}{2,903} = 16.57 \text{ ksi}$

RW FORM 3

RALPH WHITEHEAD & ASSOCS.
CONSULTING ENGINEERS
1936 E. SEVENTH STREET
CHARLOTTE, N. C.

BY RA DATE 7-2-76 SHEET NO. 8 OF
CKD. BY JEF DATE 7-2-76 JOB NO. C-1297
SUBJECT SCL Bridge
Cooper Rr. Redir. Channel

Steel Girder

Total steel stresses: Top = 6.88 + 9.14 = 11.02 KSI
Bott. = 9.13 + 16.57 = 20.7 KSI
3.5% over

change bottom plate to 16" × 1 7/8"

Section weight: 12" × 3/4" = 30.6 #/FT
69 3/8" × 1/2" = 117.9
16" × 1 7/8" = 102.0
251 #/FT.

2 girders = 2 × 251 × 62'-11" = 31,589 #
Diaph., stiffeners, bracing, etc. 20% = 6,310
Bearings 4 × 600 #/ea. = 2,400
40,299 #

Each main span: Use 40,300 #

Estimated cost per L.F. of main span:

Quantities:
Concrete - slab 14' × 12 1/2" = 14.58 ft²
12' × 3/4" = 0.75
curbs 2 × 1.33 × 1.0 = 2.66
end walls: 2[2.75 × 1.583 × 8.0] ÷ 63.25 = 1.10
19.09 ÷ 27 = 0.707 C.Y./L.F.

Reinforcing = 0.707 × 280 #/C.Y. = 198 #/L.F.

Struct. Steel = 40,300 / 63.25 = 637 #/L.F.

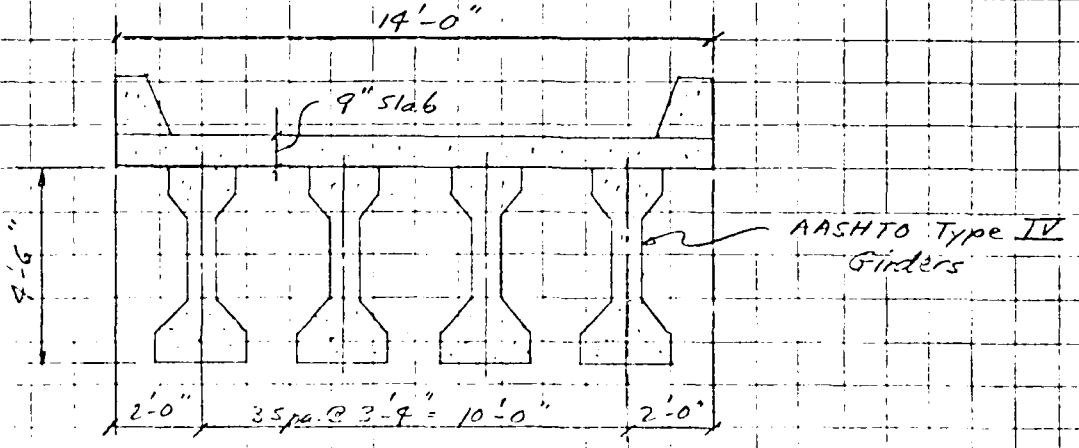
Cost:
Concrete: 0.707 @ $150.00 = $106.0
Reinf. Steel: 198 @ $0.30 = 59.4
Struct. Steel: 637 @ $0.50 = 318.5
$483.9

Cost = $4.84.00 /L.F. of span

RW FORM 3

(c)

Precast Prestressed Concrete Spans



Main Span Sections

RALPH WHITEHEAD & ASSOCS.
CONSULTING ENGINEERS
1936 E. SEVENTH STREET
CHARLOTTE, N. C.

BY RA DATE 2-13-76 SHEET NO. 10 OF ____
CKD. BY JEF DATE 2-23-76 JOB NO. C 1297
SUBJECT Cooper River Rediversion Canal

Prestressed Concrete Spans: End spans 41'-0" & 43'-0" } 590' Bridge
Main spans 8 @ 63'-3"

63'-3" span: 61'-6" c-c brgs.

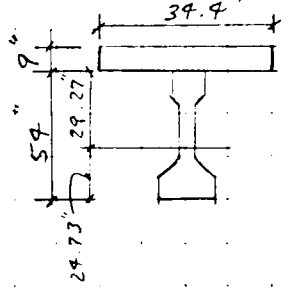
dead loads: deck - $0.75 \times 3.33 \times .15 = 0.375$ K/FT.
girder - 0.822 K/FT
Non-comp. D.L. = 1.197 K/FT

track 200/4 = 0.050
ballast $1.25 \times 3.33 \times .12 = 0.500$
curbs $2 \times 1.33 \times 1.0 \times .15/4 = 0.100$
Comp. D.L. = 0.650 K/FT

deck conc. f'_c = 3700 PSI E_c = 3688 $n = 1.162$
prest. conc f'_c = 5000 PSI E_c = 4287

eff slab width = $40/1.162 = 34.4$"

Comp. section



Girder alone
$A = 789 \text{ in}^2$
$I = 260{,}730 \text{ in}^4$

slab: $A = 34.4 \times 9 = 309.6 \text{ in}^2$
$I_0 = 2090 \text{ in}^4$

$$\bar{y} = \frac{(789 \times 29.73) + 309.6(58.5)}{789 + 309.6} = 34.25"$$

$$I_{comp.} = 260{,}730 + \underset{71507}{789(9.52)^2} + 2090 + \underset{182069}{309.6(24.25)^2} = 516{,}391 \text{ in}^4$$

Moments

$M_{DL(NON\,COMP)} = \frac{1}{8}(1.197)(61.5)^2 = 566^{k'}$
$M_{DL(COMP)} = \frac{1}{8}(.65)(61.5)^2 = 307^{k'}$

RW FORM 3

Prestressed Girder

M_{LL} (E72) = 678.5 × 7.2 = 4885 k'/Track

Impact = $35 - \frac{3782}{500}$ = 27.4 %

$M_{LL+I} = \frac{4885 \times 1.274}{4}$ = 1556 k'/girder

Midspan stresses

	Bott. gird.		Top gird.	
Noncomp. D.L.	$\frac{566\times12}{10543}$	= 649 PSI	$\frac{566\times12}{8908}$	= 762 PSI
Comp. D.L.	$\frac{307\times12}{15077}$	= 244	$\frac{307\times12}{26146}$	= 141
LL + I	$\frac{1556\times12}{15077}$	= 1,238	$\frac{1556\times12}{26146}$	= 714
		− 2,126 PSI		1,617 PSI

Top of deck: $\frac{(307+1556)12}{17961}$ = 1,245 PSI ok

Prestressing

½"ϕ S.R. strands f'_s = 270,000 psi
A = 0.153 in.²

Final Conditions

Effective prestr. force (after all losses)

F_p = 0.55(270,000)(.153) = 22,720 #/strand (max.)

allowable final stresses: $f_{comp.}$ = 2000 psi (f'_c = 5,000)
$f_{tension}$ = 0

32 strands 12 - 2" up from bottom k = 6.50"
12 - 4" up " e = 24.73 − 6.50 = 18.23"
6 - 6" up "
2 - 50" up "
32

P = 32 × 22.72 = 727 k P/A = + 921 PSI

Pe = 727 × 18.23 = 13,253 k-in

Prestressed Girder

prestress $f_{top} = \frac{13\,253}{8908} = 1,488$ PSI

$f_{bott.} = \frac{13,253}{10543} = 1,257$ PSI

final stresses: top gird. = +1,617+921−1,488 = +1,050 psi OK
(DL+LL+I + prestress) bott. gird. = −2,126+921+1,257 = +52 psi OK

Initial Conditions
Initial prestr. losses: Use 7% (A.R.E.A. pg. 8-17-42)

$F_p = 0.70(270,000)(0.93)(.153) = 26,900^{\#}$/strand

allowable initial stresses (f'_c = 4,000 psi @ release)
$f_{comp.} = 2,400$ psi
$f_{tension} = 190$ psi (no mild reinf.)
$= 380$ psi (with " ")

Midspan: $M_{DL(girder)} = \frac{1}{8}(.822)(61.5)^2 = 389^{k'}$
$P = 32 \times 26.9 = 860.8^{k}$
$P_e = 860.8 \times 18.23 = 15,690^{k\text{-}in}$

$f_{Top} = \frac{860.8}{789}^{1.091} + \frac{389\times12}{8908}^{.524} - \frac{15,690}{8908}^{1.761} = -0.146$ PSI < 0.170 OK

$f_{Bott.} = 1.091 - \frac{389\times12}{10543}^{.443} + \frac{15,690}{10543}^{1.488} = 2.136$ PSI < 2.40 OK

End of Girder:
deflect 6 strands $P_e = 860.8 \times 11.85 = 10,200^{k\text{-}in}$
10 @ 2" up
10 @ 4" up
4 @ 6" up
2 @ 36" "
2 @ 38" "
2 @ 70" "
2 @ 50" "

$f_{TOP} = 1.091 - \frac{10,200}{8908} = -54$ PSI OK

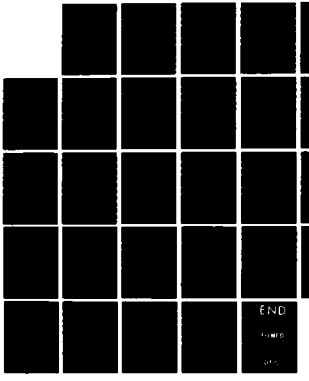
$f_{Bott} = 1.091 + \frac{10,200}{10543} = 2.058$ PSI OK

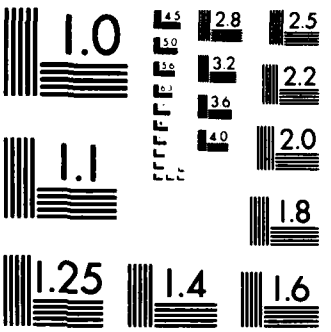
$\bar{k} = 12.88"$ $e = 11.85"$

∴ Normal amount of prestressing sufficient for loads.

AD-A149 730 COOPER RIVER REDIVERSION PROJECT LAKE MOULTRIE AND SANTEE RIVER SOUTH CRR. (U) CORPS OF ENGINEERS CHARLESTON SC CHARLESTON DISTRICT AUG 76 2/2

UNCLASSIFIED F/G 13/2 NL





RALPH WHITEHEAD & ASSOCS.
CONSULTING ENGINEERS
1936 E. SEVENTH STREET
CHARLOTTE, N. C.

BY RA DATE 2-16-76 SHEET NO. 13 OF
CKD. BY JEF DATE 2-23-76 JOB NO. C-1297
SUBJECT Cooper River Rediversion Canal Rev. 12-27-76

Prestressed Girder

Shear: check @ ¼ Point $V_{DL} = \frac{1}{4}(1.847)(61.5) = 28.4^k$

¼ pt. = 15.38' from ℄ Brg.

$V_{LL+I} = 244\left(\frac{7.2}{8.0}\right)\left(\frac{1.274}{4}\right) = 70.0^k$

$V_u(\text{¼pt.}) = 1.75(28.4) + 2.3(70.0) = 212^k$

$V_c = 0.18(8)(.88)(50.4) = 63.9^k$

$$A_v = \frac{0.5(212 - 63.9)s}{40(.88)(50.4)} = 0.042\,s$$

Using #4 $A_v = 0.40\ in^2$ $s = 9\frac{1}{2}"$ ∴ average amount of web reinf. req'd.

Check horizontal shear stress between slab & girder

$V_{DL} = \frac{1}{2}(0.650)(61.5) = 20.0^k$

$V_{LL+I} = 49.7(7.2)1.274/4 = 114^k$

$V_u = 1.75(20) + 2.3(114) = 297^k$

$Q = 309.6 \times 24.25 = 7508\ in^3$

$$v = \frac{297{,}000 \times 7508}{516{,}391 \times 20} = 216\ psi \quad OK$$

4 - Type III girders adequate for span length & loads.

RW. FORM 3

RALPH WHITEHEAD & ASSOCS,
CONSULTING ENGINEERS
1936 E. SEVENTH STREET
CHARLOTTE, N. C.

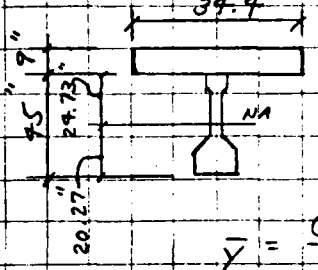
BY RA DATE 2-20-76 SHEET NO. 14 OF ____
CKD. BY JEF DATE 2-23-76 JOB NO. C-1297
SUBJECT Cooper River Rediversion Canal

Prestressed Girder

93'-0" span : 91'-6" c-c brgs.

Shear stress along contact surface between slab and girder:

Composite section (45" girder)



Girder alone
$A = 560\ in^2$ $I = 125{,}390\ in^4$

slab: $A = 309.6\ in^2$ $I_o = 2090\ in^4$

$$\bar{y} = \frac{(560 \times 20.27) + (309.6 \times 49.5)}{560 + 309.6} = 30.68"$$

$$I_{comp.} = 125{,}390 + 560(10.41)^2 + 2090 + 309.6(18.82)^2 = 297{,}820\ in^4$$

$$Q = 309.6(18.82) = 5827\ in^3$$

Composite D.L. = 0.650 k/ft. per girder

Impact $35 - \frac{1722}{500} = 31.6\%$

$$V_{DL} = \frac{1}{2}(.650)(91.5) = 13.5^k$$

$$V_{LL+I} = (38.8 \times 7.2)\,1.316\ ^k/_{ft} = 91.9^k$$

$$V_u = 1.83(13.5) + 2.3(91.9) = 236^k$$

$$v = \frac{236{,}000 \times 5827}{297{,}820 \times 16} = 289\ psi$$

Connection between slab and girder can be detailed to transfer this shear stress.

4 - Type III girders will be adequate for moments and shears

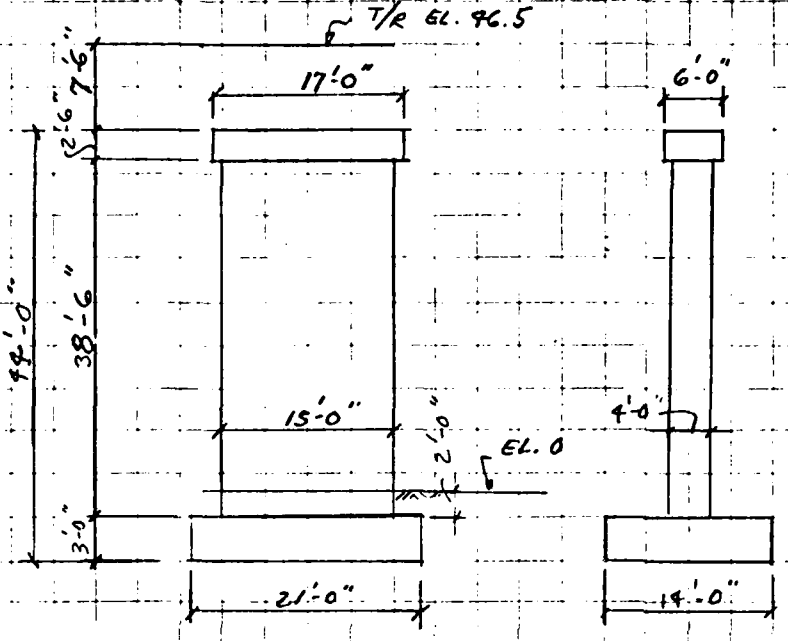
RW. FORM 3

RALPH WHITEHEAD & ASSOCS.
CONSULTING ENGINEERS
1936 E. SEVENTH STREET
CHARLOTTE, N. C.

BY RA DATE 2-16-76 SHEET NO. 15 OF ____
CKD. BY JEF DATE 3-2-76 JOB NO. C-1292
SUBJECT S.C.L. Bridge Over Cooper Rv. Rediversion Canal

(d)

Design - Main Piers 63'-3" spans



Dead Loads

track		0.200 k/Ft.
tie & ballast	12.0×1.25×.12	= 1.800
deck & curbs		= 2.067
girders	9× 0.822	= 3.288
diaphragms		= 0.200
Superstructure		= 7.555 k/Ft.

Pier: Cap $(11\times6+\pi\times\frac{6^2}{4})\times2.5\times.15$ = 35.3 k

Shaft $(11\times9.0+\pi\times\frac{9^2}{4})\times38.5\times.15$ = 326.7

Footing $21\times19\times3\times.15$ = 132.3

494 k

Earth: $(19\times21-64)\,2.0\times.12$ = 55 k

RW. FORM 3

RALPH WHITEHEAD & ASSOCS.
CONSULTING ENGINEERS
1936 E. SEVENTH STREET
CHARLOTTE, N. C.

BY RA DATE 2-16-76 SHEET NO. 16 OF
CKD. BY JEF DATE 3-2-76 JOB NO. C-1297
SUBJECT S.C.L. Bridge Over Cooper Rv. Rediv. Canal

Main piers

Super R_{DL} = 63.25 (7.555)	=	478 k
E 72 L.L. = 80.6 × 7.2	=	580 k
Pier wt.	=	494 k
Earth wt.	=	55
Total	=	1607 k

Other Forces

1.) Long. force = $0.15\left(\frac{590}{1200}\right)(655^k) = 48.3^k$

$M_{L.F.} = 48.3^k \times 44' = 2125^{k'}$

2.) Wind on train = 0.30 × 63.25 = 19.0 k

$M_{W.T.} = 19.0^k \times 59.5' = 1131^{k'}$

3.) Wind on struct. = 0.03 × 7.08 × 63.25 = 13.4 k

$M_{W.S.} = 13.4^k \times 48.0' = 643^{k'}$

4.) Wind on pier (no water)

$M_{W.P.} = [6.0 \times 2.5 \times 42.75 + 4.0 \times 36.5 \times 23.25].03 = 121^{k'}$

5.) Stream flow + buoyancy (water @ top of pier)

stream flow = $\frac{2}{3}(3.0)^2 = 6$ PSF

$M = \left(\frac{6}{30}\right)(121) = 24.2^{k'}$

buoyant force : pier = 3295 C.F. × .0629	=	206 k
earth	=	27
	−	233 k

RW. FORM 3

266
CF 86
5.82

RALPH WHITEHEAD & ASSOCS.
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1936 E. SEVENTH STREET
CHARLOTTE, N. C.

BY R.A. DATE 2-16-76 SHEET NO. 17 OF ____
CKD. BY JEF DATE 3-2-76 JOB NO. C-1297
SUBJECT S.C.L. Bridge Over Cooper Rv. Redir. Canal

Main piers

Foundation pressures

Footing: Area = $21 \times 19 = 299\ ft^2$

$S_{SHORT} = \frac{1}{6} \times 21 \times 19^2 = 686\ ft^3$

$S_{LONG} = \frac{1}{6} \times 19 \times 21^2 = 1029\ ft^3$

1.) Basic Loads: $p = \frac{1607}{299} = 5.47$ KSF ok

ok for streamflow + buoyancy also

2.) Combined Loading (25% increase in allowable pressure)

a.) Basic + L.F. + W.T. + W.S. + W.P.

$$p = 5.47 \pm \frac{\overset{3.10}{2125}}{686} \pm \frac{\overset{1.84}{1131+643+121}}{1029} = \begin{matrix} 10.91\ \text{KSF Max.} \\ 0.53\ \text{KSF Min.} \\ \text{OK} \end{matrix}$$

b.) Basic + L.F. + W.T. + W.S. + W.P. + Stream. + buoy.

$$p = 5.47 - \frac{\overset{.79}{233}}{299} \pm 3.10 \pm \frac{\overset{1.75}{1131+643+24}}{1029} = \begin{matrix} 9.53\ \text{KSF Max.} \\ -0.17\ \text{KSF Min.} \\ \text{OK} \end{matrix}$$

∴ Foundation pressures are within allowable of 5 T.S.F.

Footing depth & shaft thickness should be adequate for loads.

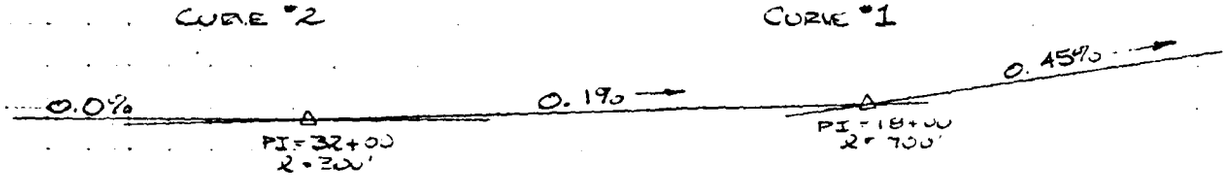
RW. FORM 3

RALPH WHITEHEAD & ASSOCS.
CONSULTING ENGINEERS
1936 E. SEVENTH STREET
CHARLOTTE, N. C.

BY JEF DATE FEB 16, '76 SHEET NO. 18 OF ___
CKD. BY ___ DATE ___ JOB NO. C-1297
SUBJECT SCL RR BR OVER COOPER RIVER REDIV CANAL

(e)

PROPOSED TRACK PROFILE



STATION	ELEVATION
1+00	54.98
2+00	54.43
3+00	53.86
4+00	53.33
5+00	52.79
6+00	52.31
7+00	51.90
8+00	51.50
9+00	51.05
10+00	50.59
11+00	50.02
12+00	49.61
13+00	49.19
14+00	48.71

1450.	48.48
1450.000	48.475
1500.	48.256
1550.	48.050
1600.	47.856
1650.	47.675
1700.	47.506
1750.	47.350
1800.	47.206
1850.	47.075
1900.	46.956
1950.	46.850
2000.	46.756
2050.	46.675
2100.	46.606
2150.000	46.550

CURVE NO. 1

RW. FORM 3

RALPH WHITEHEAD & ASSOCS.
CONSULTING ENGINEERS
1936 E. SEVENTH STREET
CHARLOTTE, N. C.

BY JEF DATE FEB 16, 1976 SHEET NO. 19 OF ____
CKD. BY ____ DATE ____ JOB NO. C-1297
SUBJECT SCLRR BRIDGE OVER COOPER RIVER REDN. CANAL

PROPOSED TRACK PROFILE (CONT'D)

STATION	ELEVATION
22+00	46.50
23+00	46.40
24+00	46.30
25+00	46.20
26+00	46.10
27+00	46.00
28+00	45.90
29+00	45.80
30+00	45.70
3050.	45.65
3050.000	45.650
3100.	45.604
3150.	45.567
3200.	45.538
3250.	45.517
3300.	45.504
3350.000	45.5
34+00	45.50
35+00	45.50
36+00	45.50
37+00	45.50
38+00	45.55
39+00	45.53
40+00	45.53
41+00	45.59
42+00	45.62
43+00	45.62
44+00	45.60
45.00	45.50

22+06 EL 46.506

PROPOSED BRIDGE (569')

27+94 EL 46.094

CURVE NO. 2

RW. FORM 3

RALPH WHITEHEAD & ASSOCS.
CONSULTING ENGINEERS
1936 E. SEVENTH STREET
CHARLOTTE, N. C.

BY JEF DATE FEB 12, '76 SHEET NO. 20 OF ____
CKD. BY ____ DATE ____ JOB NO. C-1297
SUBJECT SCLRR BRIDGE OVER
COOPER RIVER RELIEF CHAN.

LENGTH OF CURVE TO PASS THROUGH STA. 22+00 @ EL 46.00

SEE HICKERSON PAGE 162 PROB "2

$g_1 = -0.45\%$ INTERSECT @ STA 21+00 AND ELEV. 45.50

$g_2 = 0.00\%$

$r = \frac{g_2 - g_1}{L} = \frac{0.45}{L}$

$E_a = 45.50 + 0.45 \times \frac{1}{2}L \Rightarrow 45.50 + 0.225L$

STATIONING OF P.C. $= 21.00 - \frac{1}{2}L$

$N = 1.00 + \frac{1}{2}L$

$g_1 N = -0.45 - 0.225L$

$(\frac{1}{2}r)N^2 = \frac{0.225}{L}(1 + \frac{1}{2}L)^2$

$E_N = E_a + (g_1 + \frac{1}{2}r_N)(N)$ ← EQUATION 66 PG. 154

$46.00 = 45.50 + 0.225L + (-0.45 - 0.225L) + [\frac{0.225}{L}(1 + L + \frac{1}{4}L^2)]$

$46.00 = 45.50 + 0.225L - 0.45 - 0.225L + \frac{0.225}{L} + 0.225 + 0.0563L^2$

$0.0563L + \frac{0.225}{L} - 0.725 = 0$

$L^2 - 12.8774L + 3.9965 = 0$

$\therefore L = 12.50$ STA. USE L = 1250'

1475.		48.313	
1475.000		48.313	
1525.		48.092	
1575.		47.881	
1625.		47.678	
1675.	$g_1 = -0.45\%$	47.485	
1725.	$g_2 = 0.00\%$	47.300	
1775.	PI = 21.00	47.125	
1825.	EL = 45.50	46.958	
1875.		46.801	
1925.		46.652	
1975.		46.513	
2025.		46.382	
2075.		46.261	CHECK WITH PROPOSED BRIDGE ELEVATIONS
2100.		46.203	
2125.		46.148	
2150.		46.095	
2175.		46.045	
2200.		45.996	✓
2225.		45.950	
2250.		45.906	
2300.		45.825	.07' LOW
2350.		45.753	
2400.		45.690	0.11' LOW
2450.		45.636	
2500.		45.591	0.11' LOW
2550.		45.555	
2600.		45.528	0.07' LOW
2650.		45.510	
2700.		45.501	✓
2725.000		45.5	TRY L=1900'

RW. FORM 3

RALPH WHITEHEAD & ASSOCS.
CONSULTING ENGINEERS
1936 E. SEVENTH STREET
CHARLOTTE, N. C.

BY JEF DATE FEB 16, '76 SHEET NO. 21 OF ____
CKD. BY ____ DATE ____ JOB NO. C-1647
SUBJECT SCL RR BRIDGE OVER COOPER RIVER REDIN CANAL

CHECK PROPOSED BRIDGE FOR FUTURE TRACK RAISE

USE L = 1400'
g_1 = 0.45%
g_2 = 0.00%
PI = 21+00
EL = 45.50

1400.	48.65			
1400.000	48.650			
1450.	48.429			
1500.	48.216			
1550.	48.011			
1600.	47.814			
1650.	47.625			
1700.	47.445			
1750.	47.272			
1800.	47.107			
1850.	46.950			
1900.	46.802			
1950.	46.661			
2000.	46.529			
2050.	46.404			
2100.	46.288			
2150.	46.179			
2200.	46.079	-0.5 =	46.58	0.09' HIGH
2250.	45.986			
2300.	45.902	" =	46.40	✓
2350.	45.825			
2400.	45.757	" =	46.26	0.04' LOW
2450.	45.697			
2500.	45.645	" =	46.15	0.05' LOW
2550.	45.600			
2600.	45.564	" =	46.06	0.04' LOW
2650.	45.536			
2700.	45.516	" =	46.02	0.02' HIGH
2750.	45.504			
2800.000	45.5	" =	46.00	✓

MAX = 5¢" LOW @ STA. 25+00 ✓

RW. FORM 3

RALPH WHITEHEAD & ASSOCS.
CONSULTING ENGINEERS
1936 E. SEVENTH STREET
CHARLOTTE, N. C.

BY JEF DATE FEB. 16, '76 SHEET NO. 22 OF ____
CKD. BY ____ DATE ____ JOB NO. C-1297
SUBJECT SCOUR BRIDGE OVER COOPER RIVER REDIV CANAL

CHECK PROPOSED BRIDGE FOR FUTURE TENK RATE (CONT'D)

TRY L = 1500'
S = -0.45%
S_2 = 0.00
PI = 21+60
EL = 45.50

COOPER RIVER REDIVERSION CANAL C-1297

1350.	48.88		
1350.000	48.875		
1400.	48.654		
1450.	48.440		
1500.	48.234		
1550.	48.035		
1600.	47.844		
1650.	47.660		
1700.	47.484		
1750.	47.315		
1800.	47.154		
1850.	47.000		
1900.	46.854		
1950.	46.715		
2000.	46.584		
2050.	46.460		
2100.	46.344		
2150.	46.235		
2200.	46.134	46.63	.3 HIGH
2250.	46.040		
2300.	45.954	46.45	.05 HIGH
2350.	45.875		
2400.	45.804	45.80	✓
2450.	45.740		
2500.	45.684	45.68	.02 LOW
2550.	45.635		
2600.	45.594	45.59	.01 LOW
2650.	45.560		
2700.	45.534	46.03	.03 HIGH
2750.	45.515		
2800.	45.504	45.50	✓
2850.000	45.5		

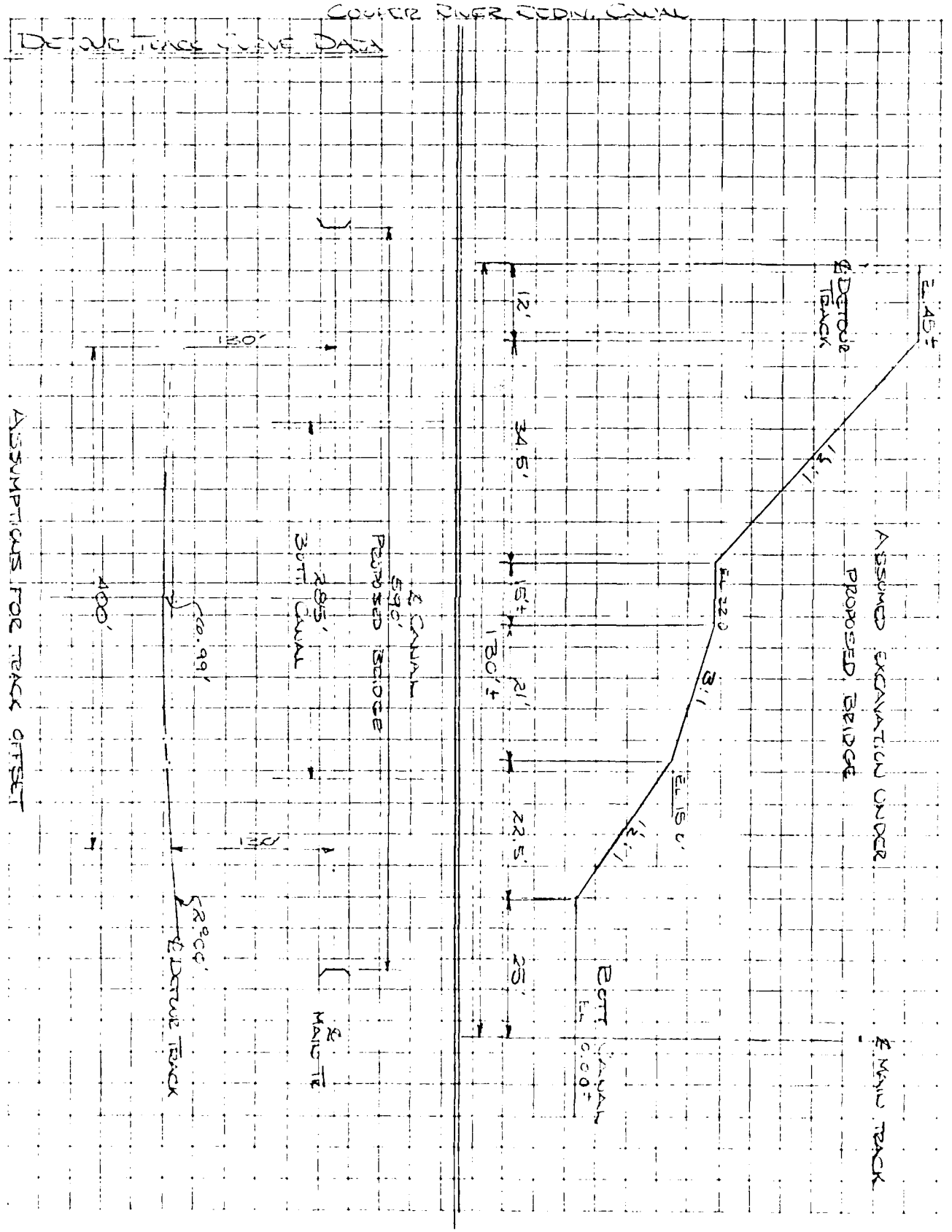
MAX = 4" LOW @ STA 25+00

RW. FORM 3

RALPH WHITEHEAD & ASSOCS.
CONSULTING ENGINEERS
1936 E. SEVENTH STREET
CHARLOTTE, N. C.

BY JEF DATE FEB. 2, '76 SHEET NO. 23 OF ____
CKD. BY ____ DATE 2-25-76 JOB NO. C-1297
SUBJECT SCL RR BRIDGE OVER COOPER RIVER DRN. CANAL

DETOUR TRACK CURVE DATA



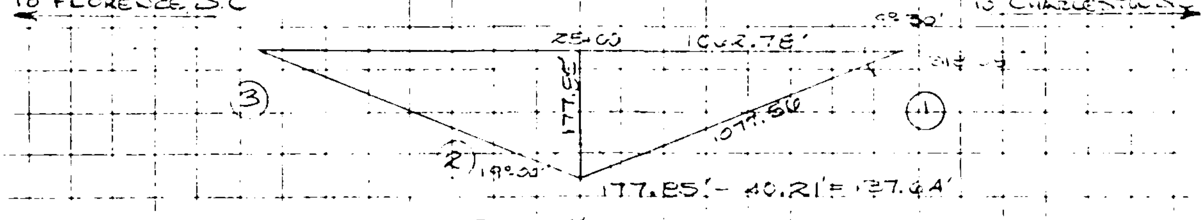
RW FORM 3

DETOUR TRACK CURVE DATA

ASSUME: D = 2°00', R = 2864.93', L_s = 160', V = 40 mph
FROM TABLES OF ALLOW. p = 0.37, q = 79.99, θ_s = 1°36'
OFFSET C-C TKS = 137'± T. BETWEEN SPIRALS = 200'
TRY: $\Delta_1 = \Delta_3$ = 9°-30', Δ_2 = 19°00'

$T_S = (R+p)\tan(\tfrac{1}{2}\Delta) + q$ $E_S = (R+p)\,\text{exsec}(\tfrac{\Delta}{2}) + p$

T_{S_1} = 318.08 E_{S_1} = 10.24'
T_{S_2} = 559.49 E_{S_2} = 40.21'



OFFSET @ STA. 25+00 = 137.64' C.C. TRACKS O.K.

CURVE DATA

	①	②	③
P.I.	14+37.22	25+13.92	35+82.22
Δ_T	9°-30'	19°-00'	9°-30'
Δ_c	6°-18'	15°-48'	6°-18'
D_c	2°-00'	2°-00'	2°-00'
T_s	318.08'	559.48'	318.08'
L_c	315.00'	790.00'	315.00'
E_s	10.24'	40.21'	10.24'
S.E.	1½"	1½"	1½"

T.S. = 11+19.14
S.C. 12+79.14
C.S. 15+94.14
S.T. 17+54.14
T.S. 19+54.14
S.C. 21+14.14
C.S. 29+04.14
S.T. 30+64.14
T.S. 32+64.14
S.C. = 34+24.14
C.S. 37+39.14
S.T. 38+99.14 = 39+80.86

RW. FORM 3

(f.)

Load Rating of Existing Bridge (Section #8)

Effective span length = 40'-5"
Dead load = 0.535 k/ft. per girder.
Two girders per span (6'-6" ctr. to ctr.)

Diesel impact factor = $\frac{100}{6.5+40} = \frac{3(40.4)^2}{1600} = 52.3\%$

M_{LL} (E50) = 839.5 k' per girder

See sheet no. 28 for girder section properties

$M_{DL} = \frac{1}{8}(.535)(40.4)^2 = 110^{k'}$

A.) Load rating in accordance with A.R.E.A. spec's, chapter 15 - part 7. (Existing Bridges)

material: open-hearth steel $F_y = 30{,}000$ p.s.i.

1.) tension (bending) $f_t = 0.8F_y = .0.8(30{,}000) = 24{,}000$ psi
compression (bending) $f_b = 0.76F_y$ (on gross section - not critical)

$M_{allowable} = 24{,}000 \times 1440/12{,}000 = 2880^{k'}$

$M_{LL+I} = 2880 - 110 = 2770^{k'}$

$M_{LL} = \frac{2770}{1.523} = 1819^{k'}$

Rated E loading $= \frac{1819}{839.5}(50) = E\text{-}109$ (based on moment)

2.) shear in web : $f_v = 0.75F_y = 22{,}500$ psi

$V = 22.5(22.5) = 506^{k}$ web plate $60 \times \frac{3}{8} = 22.5 in^2$

$V_{LL+I} = 506 - 10.8 = 495.2^{k}$

$V_{LL} = \frac{495}{1.523} = 325^{k}$

E rating $= \frac{32.5}{95.1}(50) = E\,170$

RW. FORM 3

Load Rating (Existing Bridge)

3.) End stiffeners : 4 - L 5 × 3½ × 7/16 Area = 14.1 in²

not critical

4.) shear on rivets (angle to web connection)

check for E 109 $V_{LL} = \frac{109}{50}(95.1) = 207^k$

$V_{LL+I} = 207(1.523) = 315^k$

$V_{DL} = \frac{-11}{304^k}$

Vertical (wheel) load = $\frac{109}{2} = 54.5^k$

$LL+I = 54.5(1.80) = 98.1^k$

$I_g \cong 40{,}800\ in^4$ (deduct one ℄, top & bot.)

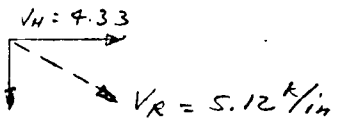
	A	Y	AY
℄	7.0 in²	.25	1.75 in³
angles	12.86 in²	2.21	28.42
	19.86 in²		30.17 in³

$\bar{Y} = 1.52''$

$Q = 19.86(30.75 - 1.52) = 581\ in^3$

Horiz. shear = $\frac{VQ}{I} = \frac{304 \times 581}{40{,}800} = 4.33^k/in$

Vert. shear = $\frac{98.1}{36''} = 2.73^k/in$



one ⅞" ℄ rivet per 2" of load (in double shear)

$V_R = 5.12^k/in \times 2'' = 10.24^k/rivet$

$f_{rivet} = \frac{10{,}240}{2 \times .60} = 8{,}530\ psi < 20{,}000$ o/k

RW FORM 3

RALPH WHITEHEAD & ASSOCS.
CONSULTING ENGINEERS
1936 E. SEVENTH STREET
CHARLOTTE, N. C.

BY RA DATE 1-29-76 SHEET NO. 27 OF
CKD. BY ACS DATE 1-30-76 JOB NO. C-1297
SUBJECT S.C.L. Bridge
Cooper River Rediversion Channel

Load Rating (Existing Bridge)

B.) Load rating based on girder section with current allowable bending stress.

For allowable bending stress, use factor of safety of 1.8 against yielding of material (.55 Fy)

For open-hearth steel, Fy = 30,000 psi
allowable tension stress (bending) = .55 × 30,000 = 16,600 psi

$M_{allowable} = 16{,}600 \times 1770 / 12{,}000 = 1992^{k'}$

$M_{LL+I} = 1992 - 110 = 1882^{k'}$

$M_{LL} = \frac{1882}{1.523} = 1236^{k'}$

Rated E loading $= \frac{1236}{834.5}(50) = E\,74.1$

Summary:
Load rating based on bending moment capacity of girder and full diesel impact.

Criteria	Coopers E Rating
A.) Allowable rating stresses as per A.R.E.A. Spec's. (Chapter 15, part 7)	E 109
B.) Allowable design stresses (F.S. = 1.8 against yielding)	E 74.1

Conclusion: Existing bridge adequate for E 72 loading with full diesel impact.

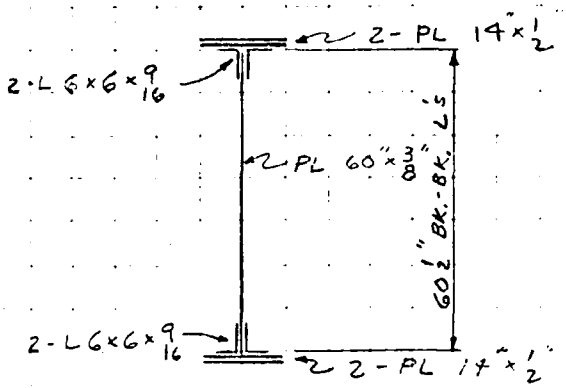
RW. FORM 3

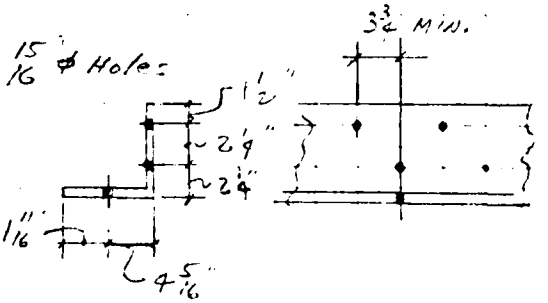
RALPH WHITEHEAD & ASSOCS.
CONSULTING ENGINEERS
1936 E. SEVENTH STREET
CHARLOTTE, N. C.

BY RA DATE 1-29-76 SHEET NO. 28 OF ____
CKD. BY ACS DATE 1-30-76 JOB NO. C-1297
SUBJECT S.C.L. Bridge
Cooper River Rediversion Channel

Load Rating (Existing Bridge)

Girder section properties at midspan





Bottom angle net section

stagger correction = $\frac{(3.75)^2}{4 \times 2.25} = 1.56" > 1"\phi$

∴ deduct 2 holes (each L)
" " " (each cover PL)
" 16 " (web PL)

Gross section: web $1/2 \times 3/8 \times 60^2$ = 6750 in⁴
angles $2[2 \times 6.43 \times (28.54)^2]$ = 20950
plates $2 \times 14.0 \times (30.75)^2$ = 26480
I_g = 54,180 in⁴

net section: web $0.375[1.75^2 + 5.25^2 + 8.75^2 + 12.25^2 + 15.75^2 + 19.25^2 + 22.75^2 + 28.0^2]$ = -809 in⁴
angles $0.563 \times 2[26.0^2 + 30.0^2]$ = -1895
plates $1.0 \times 2 \times 30.75^2$ = -1891
$-4595 \times 2 = 9190 in^4$

I_{net} = 44,990 in⁴

$S_{net} = \frac{44,990}{31.25} = 1440 in^3$.

RW FORM 3

(g)

Detour Embankment - Slope Stability

Reference: Engineering and Design
Stability of Earth and Rock-Fill Dams
EM 1110-2-1902

A. Soil Parameters:

1) Embankment material -
Values from lab tests for sample C-1 taken from borings BA-1 & BA-2 (borrow area)
$G = 2.66$ $e = 0.535$; compute γ_m, γ_{SAT}, γ'

Use $S = 60\%$ $\gamma_m = \frac{(G + S \times e)}{1+e}\gamma_w = 121\ ^{lb}/_{C.F.}$

$\gamma_{SAT} = \frac{(G+e)}{1+e}\gamma_w = 130\ ^{lb}/_{C.F.}$

$\gamma' = \gamma_{SAT} - \gamma_w = 67\ ^{lb}/_{C.F.}$

Q test : $c = 0.92$ KSF $\phi = 19.5°$ } one test each
R test : $c = 0.96$ KSF $\phi = 14.5°$ }

2.) Foundation material -
Use following values (furnished by Charleston District) as being representative of in-place foundation material

$\gamma_m = 108\ ^{lb}/_{C.F.}$ $\gamma_{SAT} = 117\ ^{lb}/_{C.F.}$ $\gamma' = 54\ ^{lb}/_{C.F.}$

Q test : $c = 0.50$ KSF $\phi = 3.5°$
R test : $c = 0.90$ KSF $\phi = 13.0°$

No S test values available, Therefore, use only R test values for Sudden Drawdown Condition

RW FORM 3

Slope stability (con't.)

B. Depth of Foundation Material:
From boring CS-20, highest line of firm material (bottom of foundation) is approx. EL. 9.0. Critical failure circles did not reach this elevation. Therefore, maximum depth of foundation is not critical for stability analysis.

C. Railroad Surcharge:
Use E72 loading with no impact
axle spacing = 5'-0"
lateral distribution: Use 10'-0"

Live Load = $72^{k}_{axle} / 5' \times 10' = 1.44\ k/s.f.$
ballast wt. = $1.17' \times 0.109\ k/cf = 0.12$
sub-ballast wt. = $0.33' \times 0.144\ k/cf = 0.05$
Total surcharge = $1.61\ k/sq.ft.$

D. Conditions to check for stability:

1.) End of construction condition
water at ground level (EL. 22.0)

2.) Sudden drawdown condition

a.) Assumed flood level at EL. 35.0 sustained to saturate embankment
b.) Assumed sudden drawdown from EL. 35.0 to water at ground level (EL. 22.0)

Solutions for critical failure circles shown on plates. Factors of safety for other failure centers are shown also.

RW. FORM 3

APPENDIX NO. "C"

COMPARATIVE COST ESTIMATES

SCLRR BRIDGE OVER COOPER RIVER REDIVERSION CANAL

COMPARATIVE COST ESTIMATES

SCHEME 1: Spans 44' - 5 @ 100' - 46' = 590' - Steel Girders (Composite)

Stone Ballast (Bridge Deck)	375 Tons @ $12.00	=	4,500	
Superstructure Conc.	404 C.Y. @ $150.00	=	60,600	
Reinforcing Steel	113,500 Lbs. @ $0.30	=	34,050	
Structural Steel	589,800 Lbs. @ $0.52	=	306,696	
Misc. Items (Drainage, Waterproofing, Timber Cross Ties, Etc.)		=	16,500	
	Superstructure Cost	=		$422,346
Substructure Conc.	660 C.Y. @ $130.00	=	85,800	
Reinforcing Steel	63,300 Lbs. @ $0.30	=	18,990	
Structure Excavation	2,650 C.Y. @ $20.00	=	53,000	
Cofferdams	4 Ea. @ $16,000	=	64,000	
Misc. Items (Drainage, Waterproofing, Piles, Etc.)		=	20,000	
	Substructure Cost	=		$241,790
	Total	=		$664,136

SCHEME 2: Spans 42' - 6 @ 84' - 44' = 590' - Steel Girders (Composite)

Stone Ballast (Bridge Deck)	375 Tons @ $12.00	=	4,500	
Superstructure Conc.	407 C.Y. @ $150.00	=	61,050	
Reinforcing Steel	114,000 Lbs. @ $0.30	=	34,200	
Structural Steel	525,200 Lbs. @ $0.52	=	273,104	
Misc. Items		=	16,500	
	Superstructure Cost	=		$389,354
Substructure Conc.	775 C.Y. @ $130.00	=	100,750	
Reinforcing Steel	73,800 Lbs. @ $0.30	=	22,140	
Structure Excavation	2,730 C.Y. @ $20.00	=	54,600	
Cofferdams	5 Ea. @ $14,400	=	72,000	
Misc. Items		=	19,000	
	Substructure Cost	=		$268,490
	Total	=		$657,844

SCHEME 3: Spans 42' - 7 @ 72' - 44' = 590' - Steel Girders (Composite)

Stone Ballast (Bridge Deck)	375 Tons @ $12.00	=	4,500	
Superstructure Conc.	410 C.Y. @ $150.00	=	61,500	
Reinforcing Steel	114,800 Lbs. @ $0.30	=	34,440	
Structural Steel	455,600 Lbs. @ $0.52	=	236,912	
Misc. Items		=	16,500	
	Superstructure Cost	=		$353,852
Substructure Conc.	865 C.Y. @ $130.00	=	112,450	
Reinforcing Steel	82,000 Lbs. @ $0.30	=	24,600	
Structure Excavation	2,830 C.Y. @ $20.00	=	56,600	
Cofferdams	6 Ea. @ $14,000	=	84,000	
Misc. Items		=	17,000	
	Substructure Cost	=		$294,650
	Total	=		$648,502

SCHEME 4: Spans 41' - 8 @ 63'-3" - 43' = 590' - Steel Girders (Composite)

Stone Ballast (Bridge Deck)	375 Tons @ $12.00	=	4,500	
Superstructure Conc.	413 C.Y. @ $150.00	=	61,950	
Reinforcing Steel	116,000 Lbs. @ $0.30	=	34,800	
Structural Steel	384,240 Lbs. @ $0.52	=	199,805	
Misc. Items		=	16,500	
	Superstructure Cost	=		$317,555
Substructure Conc.	945 C.Y. @ $130.00	=	122,850	
Reinforcing Steel	89,300 Lbs. @ $0.30	=	26,790	
Structure Excavation	2,990 C.Y. @ $20.00	=	59,800	
Cofferdams	7 Ea. @ $14,000	=	98,000	
Misc. Items		=	15,000	
	Substructure Cost	=		$322,440
	Total	=		$639,995

SCHEME 5: Spans 41' - 8 @ 63'-3" - 43' = 590' (Same as Scheme 4) Precast, Prestressed Concrete Girders for Superstructure (Composite)

Stone Ballast (Bridge Deck)	375 Tons @ $12.00	=	4,500	
Superstructure Conc.	326 C.Y. @ $160.00	=	52,160	
Reinforcing Steel	74,500 Lbs. @ $0.30	=	22,350	
45" Concrete Girders	335 L.F. @ $65.00	=	21,775	
54" Concrete Girders	2,015 L.F. @ $75.00	=	151,125	
Misc. Items		=	16,500	
	Superstructure Cost	=		$268,410
Substructure Conc.	970 C.Y. @ $130.00	=	126,100	
Reinforcing Steel	91,600 Lbs. @ $0.30	=	27,480	
Structure Excavation	2,990 C.Y. @ $20.00	=	59,800	
Cofferdams	7 Ea. @ $14,000	=	98,000	
Misc. Items		=	15,000	
	Substructure Cost	=		$326,380
	Total	=		$594,790

SCHEME 6: Spans 41' - 8 @ 63'-3" - 43' = 590' (Same as Scheme 4) Steel Girders and Timber Deck

Structural Steel	464,000 Lbs. @ $0.52	=	241,280	
Creo. Timber Deck	38.0 M.B.M. @ $1,000	=	38,000	
Hardware (Timber Deck)	1,800 Lbs. @ $3.00	=	5,400	
	Superstructure Cost	=		$284,680
Substructure Conc.	885 C.Y. @ $130.00	=	115,050	
Reinforcing Steel	83,900 Lbs. @ $0.30	=	25,170	
Structure Excavation	2,990 C.Y. @ $20.00	=	59,800	
Cofferdams	7 Ea. @ $14,000	=	98,000	
Misc. Items		=	15,000	
	Substructure Cost	=		$313,020
	Total	=		$597,700

COMPARATIVE COST ESTIMATES FOR BRIDGE - SUMMARY

Scheme 1: Steel spans 44' - 5 @ 100' - 46' = 590' Length (Composite)

Superstructure Cost	=	$422,346
Substructure Cost	=	241,790
Total Cost	=	$664,136

Scheme 2: Steel spans 42' - 6 @ 84' - 44' = 590' Length (Composite)

Superstructure Cost	=	$389,354
Substructure Cost	=	268,490
Total Cost	=	$657,844

Scheme 3: Steel spans 42' - 7 @ 72' - 44' = 590' Length (Composite)

Superstructure Cost	=	$353,852
Substructure Cost	=	294,650
Total Cost	=	$648,502

Scheme 4: Steel spans 41' - 8 @ 63'-3" - 43' = 590' Length (Composite)

Superstructure Cost	=	$317,555
Substructure Cost	=	322,440
Total Cost	=	$639,995

Scheme 5: Prestressed Concrete Girder spans 41' - 8 @ 63'-3" - 43' = 590' Length (Composite)

Superstructure Cost	=	$268,410
Substructure Cost	=	326,380
Total Cost	=	$594,790

Scheme 6: Steel spans 41' - 8 @ 63'-3" - 43' = 590' Length Steel Girders and Timber Deck

Superstructure Cost	=	$284,680
Substructure Cost	=	313,020
Total Cost	=	$597,700

Conclusion: Scheme 5 presents least cost of structure. Maximum span length for 54" deep prestressed concrete girders (approximately 65 feet) prevents closer balance between superstructure and substructure costs.

APPENDIX NO. "D"

BORING LOGS AND SOIL DATA

Hole No. CS - 20

DRILLING LOG	DIVISION: South Atlantic
INSTALLATION: Charleston District	SHEET 1 OF 1 SHEETS
1. PROJECT: Copper River Rediversion	10. SIZE AND TYPE OF BIT: 1 3/8" split spoon & 2 1/2" core
2. LOCATION (Coordinates or Station): N 361,730 E 2,351,350	11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL
3. DRILLING AGENCY: Savannah District Corps of Engineers	12. MANUFACTURER'S DESIGNATION OF DRILL: Dorico 1250
4. HOLE NO. (As shown on drawing title and file number): CS - 20	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 7, UNDISTURBED 0
5. NAME OF DRILLER: Mc Alister	14. TOTAL NUMBER CORE BOXES: 0
6. DIRECTION OF HOLE: ☑ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER: 23.0
7. THICKNESS OF OVERBURDEN: 51.0	16. DATE HOLE: STARTED 14 Dec. 70, COMPLETED 15 Dec. 70
8. DEPTH DRILLED INTO ROCK: 0	17. ELEVATION TOP OF HOLE: 23.9
9. TOTAL DEPTH OF HOLE: 51.0'	18. TOTAL CORE RECOVERY FOR BORING: 0
	19. SIGNATURE OF INSPECTOR: G. J. Krounak

ELEVATION 23.9 a	DEPTH 0 b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY (RQD) e	BOX OR SAMPLE NO f	REMARKS (Drilling time, water loss, depth of weathering, type of sampler) g	B/F
EL 23.0 ▽			brown clayey Sand (SC) w/ roots	55.1	1	W.T. @ 0.0 12 hrs after hole completion - W.T. @ 2.0 during drilling.	10
			brown & tan inorganic silt (MH)	31.5	2		11
			gray tan lean clay (CL)	26.6	3		7
							17
							18
							19
13.9	10		greyish tan silty Sand (SM)	20.3	4		9
			gray lean clay (CL)	34.0	5		22
							19
							51
							45
							49
EL. 3.5	20						44
							46
			light grey silty fine Sand (SM) w/ seams of grey fat clay, CH	27.3	6		77
							49
							51
							100/0.9'
-6.1	30						87
							66
							67
							65
							97
							96
							93
							92
-16.1	40						100/0.5'
							100/0.4'
							100/0.3'
							100/0.3'
							100/0.4'
							100/0.5'
							100/0.3'
-26.1	50		dark grey silty coarse Sand (SM) w/ some rock fragments	14.8	7		100/0.3'
	51						
			final log, corrected after laboratory classifications				C/F • Blows per foot required to drive a 1 3/8" split spoon w/ 140 # hammer falling 30"
			Bottom of Hole				

Hole No. CS - 20A

DRILLING LOG	DIVISION: South Atlantic	INSTALLATION: Charleston District	SHEET 1 OF 1 SHEETS

1. PROJECT: Cooper River Rediversion
2. LOCATION (Coordinates or Station): 581,270 / 2,331,060
3. DRILLING AGENCY: Savannah District Corps of Engineers
4. HOLE NO. (As shown on drawing title and file number): CS - 20A
5. NAME OF DRILLER: Mc Alister
6. DIRECTION OF HOLE: [x] VERTICAL [ ] INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: 14.4'
8. DEPTH DRILLED INTO ROCK: 10.6'
9. TOTAL DEPTH OF HOLE: 25.0'
10. SIZE AND TYPE OF BIT: 1 3/8" Split Spoon & 4" Rock Bit
11. DATUM FOR ELEVATION SHOWN (GS or MSL): MSL
12. MANUFACTURER'S DESIGNATION OF DRILL: Damco 1250
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 7; UNDISTURBED 0
14. TOTAL NUMBER CORE BOXES: 1
15. ELEVATION GROUND WATER: 25.3 11 Dec 70
16. DATE HOLE: STARTED 10 Dec. 70; COMPLETED 11 Dec. 70
17. ELEVATION TOP OF HOLE: 26.0
18. TOTAL CORE RECOVERY FOR BORING: 67
19. SIGNATURE OF INSPECTOR: G. J. Kraunak

ELEVATION 26.0' a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY or e %W	BOX OR SAMPLE NO. f	* B/F g	REMARKS (Drilling time, water loss, depth of weathering, etc.) h
25.5 S			brown lean Clay (CL) w/ roots	34.4	1	6	W.T. @ 0.7' 12 hrs after hole completion. W.T. @ 7.5' during drilling
			brown inorganic Silt (MH)	42.9	2	7	
						6	
			brown & gray inorganic Silt (MH)	32.5	3	13	
						11	
			lt. gray clayey Sand (SC)	21.5	4	24	
	10		tan silty Sand (SM - SM)	17.9	5	16	
			tan & grey sandy lean Clay (CL) w/ gravel	27.7	6	50	
			gray, silty, clayey Sand (SM - SC)	22.5	7	70	100/0.4'
			SANDSTONE : gray, fine grained, calcareous, well indurated	60 %			pull # 1, 14.4 - 17.0', run 2.6', rec. 1.5', CL 1.1'
	20		17.0' - 19.2' unindurated		Box 1		pull # 2 17.0 - 25.0
El. 3.5			19.2' - 22.6' slt. indurated	75 %			run 8.0'
			22.6' - 25.0' unindurated				rec. 6.0'
	25						cl 2.0'
			final log corrected after laboratory classification				* B/F = blows per foot required to drive a 1 3/8" O.D. split spoon w/ 140 # hammer falling 30"

Hole No. CS - 20 B

DRILLING LOG	DIVISION: South Atlantic	INSTALLATION: Charleston District	SHEET 1 OF 1 SHEETS

1. PROJECT: Cooper River Rediversion
2. LOCATION (Coordinates or Station): N 552,220 E 2,331,340
3. DRILLING AGENCY: Savannah District Corps of Engineers
4. HOLE NO. (As shown on drawing title and file number): CS - 20 B
5. NAME OF DRILLER: Mc Allister
6. DIRECTION OF HOLE: ☑ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: 51.0
8. DEPTH DRILLED INTO ROCK: 0
9. TOTAL DEPTH OF HOLE: 51.0'
10. SIZE AND TYPE OF BIT: 1 3/8" Split spoon
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL
12. MANUFACTURER'S DESIGNATION OF DRILL: Damco 12=0
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 8; UNDISTURBED 0
14. TOTAL NUMBER CORE BOXES: 0
15. ELEVATION GROUND WATER: 23.3, 17 Dec. 70
16. DATE HOLE: STARTED 15 Dec. 70; COMPLETED 17 Dec. 70
17. ELEVATION TOP OF HOLE: 26.0
18. TOTAL CORE RECOVERY FOR BORING: 0
19. SIGNATURE OF INSPECTOR: G. J. Kraynak

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	CORE RECOVERY %	BOX OR SAMPLE NO. Jar No.	B/F* e	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) e
			brown lean Clay w/trace of fine Sand (CL)	25.5	1	6 9	W.T. @ 2.7' 30 hrs after hole completed. W.T. @ 3.1 during drilling
El. 23.3 ▽			tan fat Clay (CH)	29.9	2	3 10 12	
16.0	10		gray & tan clayey Sand (SC)	18.7	3	26 19 23	
			gray inorganic Silt, low LL (ML) w/ Sand & Gravel Sizes	24.8	4	66 100/0.5' 100/0.2'	
			gray fat Clay (CH) w/pockets of lt. gray Silt	25.2	5	55 55	
	20		dark gray clayey fine Sand (SC)			100/0.8' 100/0.2'	
El. 3.5			gray silty Sand (SM)	24.7	6	64 100/0.9' 100/0.7'	
-4.0	30					91 83 63 67 74 81 87 91	
-14.0	40					100/0.8' 100/0.6' 100/0.5' 100/0.5'	
			dark gray lean Clay (CL)	24.4	7	100/0.4' 100/0.5'	
-24.0	50		gray silty Sand (SM)	16.7	8	100/0.6' 100/0.8'	
			final Log corrected after laboratory classifications				
			Bottom of Hole				

* B/F = Blows per foot required to drive a 1 3/8" I.D. splitspoon w/ 140 lb. hammer falling 30"

Hole No. R-1

DRILLING LOG	DIVISION: South Atlantic	INSTALLATION: Charleston District	SHEET 1 OF 2 SHEETS
1. PROJECT: Cooper River Rediversion		10. SIZE AND TYPE OF BIT: 1 3/8" ø SSS & ARL Bit	
2. LOCATION (Coordinates or Station): N581,600 E2,331,160		11. DATUM FOR ELEVATION SHOWN (MSL or MLL): MSL	
3. DRILLING AGENCY: Mobile District		12. MANUFACTURER'S DESIGNATION OF DRILL: Failing 314	
4. HOLE NO. (As shown on drawing title and file number): R-1		13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 4; UNDISTURBED -	
5. NAME OF DRILLER: Pardon		14. TOTAL NUMBER CORE BOXES: 4	
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.		15. ELEVATION GROUND WATER: 16.9	
7. THICKNESS OF OVERBURDEN: 15.0		16. DATE HOLE: STARTED 6 Oct 75; COMPLETED 6 Oct 75	
8. DEPTH DRILLED INTO ROCK: 42.5		17. ELEVATION TOP OF HOLE: 23.4	
9. TOTAL DEPTH OF HOLE: 57.5'		18. TOTAL CORE RECOVERY FOR BORING: %	
		19. SIGNATURE OF INSPECTOR: C. Davis	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc.; if significant) g
23.4	0.0		Top of Hole			Blows/Ft
			CL - Silty clay - Tan & Gray		1	15 19 20
18.4	5.0				2	25 Ground Water @ 16.9
			SM - Silty Fine and Med. Sand Gray		3	16 18 20 18
13.4	10.0					
			ML - Calcareous Clayey Silt Gray		4	24 28
8.4	15.0		~~Top of Rock 15.0'~~			Refusal @
			Sandstone, grey, soft, calcareous with silty matrix		Core Box 1	Pull - 1 15.0 - 20.5 Run 5.5 Rec 3.7 C/L 1.8
3.4	20.0					
					Core Box 2	Pull - 2 20.5 - 25.0 Run 4.5 Rec 5.3 C/G 0.8
-1.6	25.0					
			Segmented with occassional mudstone lamallie, flaggy			Pull - 3 25.0 - 28.8 Run 3.8 Rec 3.5 C/L 2.3
-6.6	30.0					
			Continue on Sheet 2			

DRILLING LOG (Cont Sheet) | ELEVATION TOP OF HOLE 23.4 | Hole No. R-1

PROJECT: Cooper River Rediversion | INSTALLATION: Charleston District | SHEET 2 of 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			Borderline siltstone, soft, unconsolidated highly friable		Core Box 2-3	Pull - 4 28.8 - 35.0' Run 6.2' Rec 1.9' C/L 4.3'
-11.6	35.0					
			Sandstone and shale, light sandstone layers segmented by horizontal to convex black shale lamallie, soft to moderately hard.		Core Box 3	Pull - 5 35.0 - 45.0 Run 10.0 Rec 5.4 C/L 4.6
-16.6	40.0					
-21.6	45.0					
					Core Box 4	Pull - 6 45.0 - 55.0 Run 10.0' Rec 9.0' C/L 1.0'
-26.6	50.0					
-31.6	55.0					
			Sandstone, [illegible] moderately hard			Pull - 7 55.0 - 57.5' Rec 2.0 Run 2.5' C/L 0.5'
34.1	57.5		Bottom of hole 57.5'			

Hole No. R-2

DRILLING LOG	DIVISION: South Atlantic	INSTALLATION: Charleston District	SHEET 1 OF 2 SHEETS

1. PROJECT: Cooper River Rediversion
2. LOCATION (Coordinates or Station): N581450 E2 351,120
3. DRILLING AGENCY: Mobile District
4. HOLE NO. (As shown on drawing title and file number): R-2
5. NAME OF DRILLER: Parden
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: 11.4
8. DEPTH DRILLED INTO ROCK: 51.7
9. TOTAL DEPTH OF HOLE: 63.1
10. SIZE AND TYPE OF BIT: 3 7/8" [illegible]
11. DATUM FOR ELEVATION SHOWN (TIM or MSL): MSL
12. MANUFACTURER'S DESIGNATION OF DRILL: Failing 314
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 2; UNDISTURBED -
14. TOTAL NUMBER CORE BOXES: 6
15. ELEVATION GROUND WATER: 16.9
16. DATE HOLE: STARTED 8 Oct. 75; COMPLETED 8 Oct. 75
17. ELEVATION TOP OF HOLE: 23.4
18. TOTAL CORE RECOVERY FOR BORING: %
19. SIGNATURE OF INSPECTOR: C. Davis

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
						Blows / Ft
23.4	0.0		Top of Hole			
			CL - Silty Clay Tan		1	10 11 11 26
18.4	5.0		SC - Clayey Fine Sand Tan			Ground Water @ 16.9
			SP - Fine & Med. Sand W/Gravel Gray		2	18 20 21
13.4	10.0					
12.0	11.4		Top of Rock			Refusal @ 11.4 +100
			Sandstone, grey, hard, very hard, very fine grain sand and silt, borderline siltstone		Core Box 1	Pull - 1 11.4 - 15.4' Run 4.0' Rec 1.3' C/L 2.7'
8.4	15.0		11.0 to 12.0 leached shell			
			Sandstone, gray, moderately hard to soft.		Core Box 1 & 2	Pull - 2 15.4 - 25.4' Run 10.0' Rec 9.5' C/L 0.5'
3.4	20.0		21.5-25.4 Friable			
-1.6	25.0					
			Sandstone and shale, dark grey, moderately hard light sandstone layers segmented by horizontal to convex black shale		Core Box 2 - 3	Pull - 3 25.4' - 35.4' Run 10.0' Rec 9.8' C/L 1.2'
-6.6	30.0					

Continue on Sheet 2

DRILLING LOG (Cont Sheet) | ELEVATION TOP OF HOLE 23.4 | Hole No. R-2

PROJECT: Cooper River Rediversion | INSTALLATION: Charleston District | SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc.; if significant) g
			Sandstone and shale, light sandstone layers segmented by horizontal to convex black shale beds lamallie, moderately hard.		Core Box 2 & 3	
-11.6	35.0					
			35.0-37.0 Massive friable sandstone 37.0 - Fragmented shell zone		Core Box 3 & 4	Pull - 4 35.4' - 45.4' Run 10.0' Rec 3.4' C/L 6.6'
-16.6	40.0					
-21.6	45.0					
			Shale - shale, black layers of shale with segmented dark grey 0.5 inch layers of sand 47.5-51.1 Fragmented shell material in mud matrix		Core Box 4 & 5	Pull - 5 45.4' - 55.4' Run 10.0' Rec 7.5' C/L 2.5'
-26.6	50.0					
-31.6	55.0				Core Box 5 & 6	Pull - 6 55.4'- 63.1' Run 7.7' Rec 7.4' C/L 0.3'
-36.6	60.0					
	63.1		Bottom of Hole 63.1			

Hole No. R-5

DRILLING LOG

DIVISION: South Atlantic

INSTALLATION: Charleston District

SHEET 1 OF 2 SHEETS

1. PROJECT: Cooper River Rediversion

2. LOCATION (Coordinates or Station): N581,410 E2,330,910

3. DRILLING AGENCY: Mobile District

4. HOLE NO. (As shown on drawing title and file number): R-5

5. NAME OF DRILLER: Parden

6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.

7. THICKNESS OF OVERBURDEN: 11.8

8. DEPTH DRILLED INTO ROCK: 51.3

9. TOTAL DEPTH OF HOLE: 63.1

10. SIZE AND TYPE OF BIT: 3 7/8" & SSS & 4x5½ BB

11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL

12. MANUFACTURER'S DESIGNATION OF DRILL: Failing 314

13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 3; UNDISTURBED -

14. TOTAL NUMBER CORE BOXES: 4

15. ELEVATION GROUND WATER: 13.9

16. DATE HOLE: STARTED 29 Sept 75; COMPLETED 29 Sept 75

17. ELEVATION TOP OF HOLE: 22.4

18. TOTAL CORE RECOVERY FOR BORING: 74.7 %

19. SIGNATURE OF INSPECTOR: C. Davis

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
						Blows / Ft
22.4	0.0		Top of Hole			
			CL-Silty Clay - Tan & Gray		1	18 17 19
17.4	5.0		SC-Clayey Fine Sand - Tan & Gray		2	17 14
12.4	10.0		SM-Silty Fine and Med. Sand Gray		3	15 34
10.6	11.8		Top of Rock 11.8"			Refusal 3 — 118
7.4	15.0		Sandstone, grey, hard, fine grain and silty, massively bedded, somewhat friable, grades to siltstone and claystone.		Core Box 1	Pull - 1 11.8 - 15.0 Run 3.2 Rec 0.6 C/L 2.6
						Pull - 2 15.0 - 17.7 Run 2.7 Rec 5.0 C/G 2.3
2.4	20.0					Pull - 3 17.7 - 20.1 Run. 2.4 Rec 2.4 C/L 0.0
-2.6	25.0		Shale, dark grey, soft to moderately hard laminated with 0.5 inch layers of sand. Hard, well cemented zone 30.0-30.5 34.0-35.0 36.0-40.1			Pull - 4 20.1 - 25.1 Run 5.0 Rec 2.8 C/L 2.2
					Core Box 2	Pull - 5 25.1 - 30.1 Run 5.0 Rec 2.0 C/L 3.0
-7.6	30.0		Continue on Sheet 2			

DRILLING LOG (Cont Sheet) | ELEVATION TOP OF HOLE 22.4 | Hole No. R-5

PROJECT: Cooper River Rediversion | INSTALLATION: Charleston District | SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			Shale, grey to dark grey, moderately hard.		Core Box 2	Pull - 6 30.1 - 35.1' Run 5.0' Rec 4.6' C/L 0.4'
-12.6	35.0					
			Sandstone, grey, moderately hard, very silty, laminated with thin clay layers			Pull - 7 35.1 - 40.1' Run 5.0' Rec 3.0' C/L 2.0'
-17.6	40.0					
			Shale, grey, dark grey, soft to moderately hard, broken and segmented wavy planes of sand included, preferred splittting along the sandy laminations.		Core Box 3	Pull - 8 40.1 - 45.1' Run 5.0' Rec 3.3' C/L 1.7'
-22.6	45.0		44.0 Claystone, black moderately hard, massive beds conchoidal fracture, occasional sand lamallie			Pull - 9 45.1 - 50.1 Run 5.0' Rec 5.3' C/G 0.3'
-27.6	50.0		54.0-55.0 Lignite zone			
					Core Box 3&4	Pull - 10 50.1 - 55.1' Run 5.0' Rec 3.3' C/L 1.7'
-32.6	55.0					
			Claystone - 55.0 Black massively bedded		Core Box 4	Pull - 11 55.1 - 60.1' Run 5.0' Rec 5.0' C/L 0.0'
-37.6	60.0					
			Grades sandy towards bottom of hole.			Pull - 12 60.1 - 63.1' Run 3.0' Rec 2.0' C/L 1.0'
-40.7	63.1					
			Bottom of Hole 63.1'			

Hole No. BA-1

DRILLING LOG	DIVISION: South Atlantic	INSTALLATION: Charleston District	SHEET 1 OF 2 SHEETS

1. PROJECT: Cooper River Rediversion
2. LOCATION (Coordinates or Station): N580,340 E2,330,085
3. DRILLING AGENCY: Mobile District
4. HOLE NO. (As shown on drawing title and file number): BA-1
5. NAME OF DRILLER: Parden
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: 31.5
8. DEPTH DRILLED INTO ROCK: 0.0
9. TOTAL DEPTH OF HOLE: 31.5
10. SIZE AND TYPE OF BIT: 1 3/8" ass & 4x5½ BPL
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL
12. MANUFACTURER'S DESIGNATION OF DRILL: Failing 314
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED 8; UNDISTURBED -
14. TOTAL NUMBER CORE BOXES: -
15. ELEVATION GROUND WATER: -
16. DATE HOLE: STARTED 20 October 75; COMPLETED 20 Oct 75
17. ELEVATION TOP OF HOLE: 41.0
18. TOTAL CORE RECOVERY FOR BORING: - %
19. SIGNATURE OF INSPECTOR: Lawson

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0.0		Top of Hole			Blows/Ft
			SM - Tan & Gray		1	29
	5.0		SC - Tan Sandy Clay		2	45 42 49 33
	10.0		SM - White Silty Sand		3	2 32 22 21
	15.0		SP-SM - White & Tan		4	16 16 9 24
	20.0				5	17 28 26
	25.0		Gravel		6	16 34 35
	30.0		Sandy Shale			33

Continue Pg 2

DRILLING LOG (Cont Sheet) | ELEVATION TOP OF HOLE | Hole No. BA-1

PROJECT: Cooper River Rediversion | INSTALLATION: Charleston District | SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS. (Drilling time, water l..., depth of weathering, etc., if significant) g
	31.5		SP - White & Tan Hard Shale W/Sandstone Lenses		8	Refused @ 31.5' 119
			Bottom of Hole @ 31.5'			

Hole No. BA-2

DRILLING LOG	DIVISION: South Atlantic	INSTALLATION: Charleston District	SHEET 1 OF 1 SHEETS

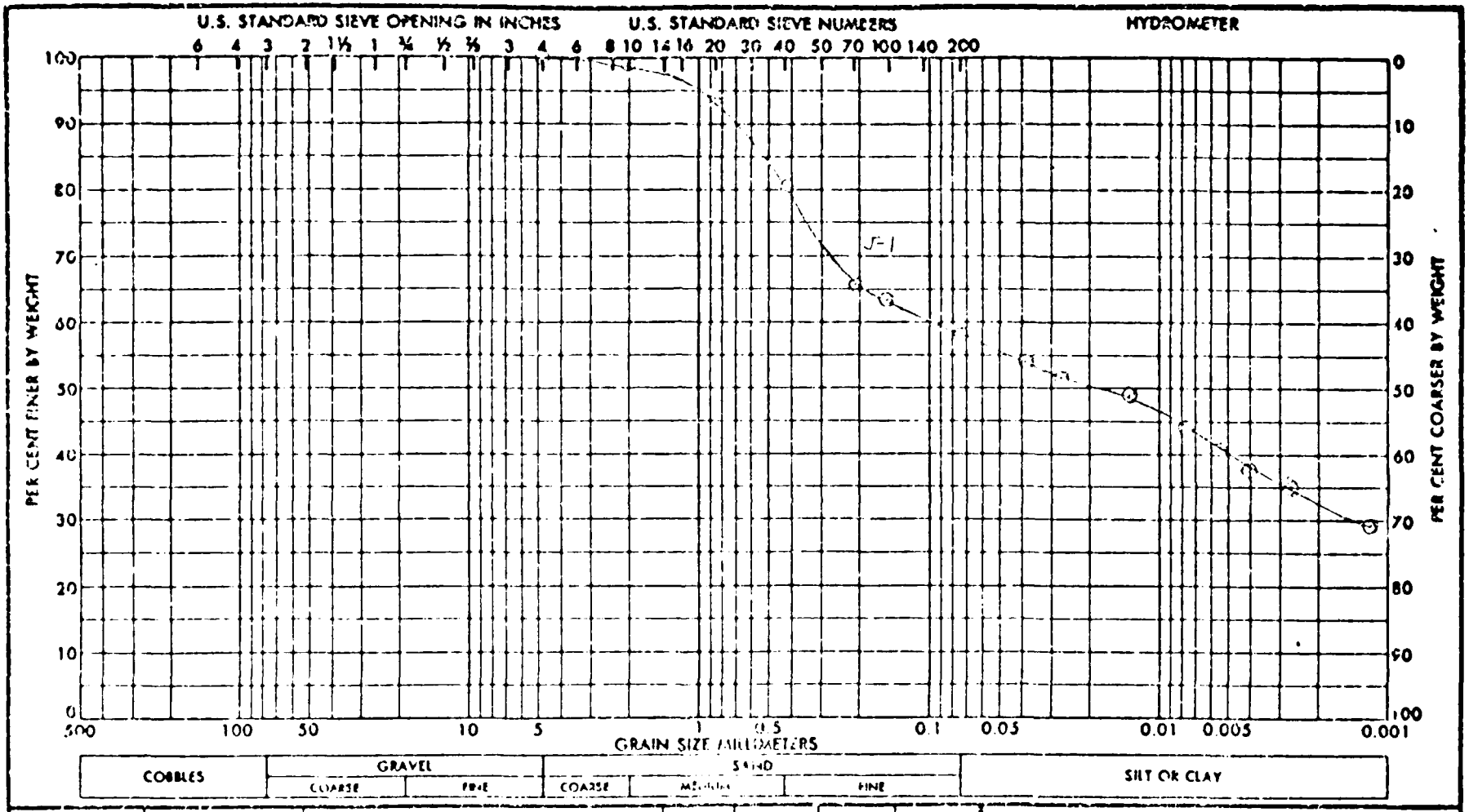
1. PROJECT: Cooper River Rediversion
2. LOCATION (Coordinates or Station): N580,870 E2,329,610
3. DRILLING AGENCY: Mobile District
4. HOLE NO. (As shown on drawing title and file number): BA-2
5. NAME OF DRILLER: Parden
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: 29.0
8. DEPTH DRILLED INTO ROCK: 0.0
9. TOTAL DEPTH OF HOLE: 29.0
10. SIZE AND TYPE OF BIT: 1 3/8" pins & [illegible]
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL
12. MANUFACTURER'S DESIGNATION OF DRILL: Failing 314
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 7; UNDISTURBED -
14. TOTAL NUMBER CORE BOXES: -
15. ELEVATION GROUND WATER: -
16. DATE HOLE: STARTED 21 Oct 75; COMPLETED 21 Oct 75
17. ELEVATION TOP OF HOLE: 34.5
18. TOTAL CORE RECOVERY FOR BORING: -
19. SIGNATURE OF INSPECTOR: Lawson

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
						Blows/Ft
	0.0		Top of Hole			
			SM - Lt. Gray Cemented Silty Sand		1	50
						55
	5.0					33
			SC - Mixed Colors Sandy Clay		2	50
						29
						27
	10.0					32
			Tan			33
						23
	15.0					16
			CL - Black Lean Clay		3	9
			MH - Black Lean Clay		4	9
			SM - Green & White Sand		5	39
	20.0		Green W/Rock Fragments			3
						28
			Tan/Black W/Rock		6	22
	25.0					53
			Gray - Black Shale W/Sand, Shells, Rock. Shale W/Siltstone Lenses		7	59
						65
	29.0					
			Bottom of Hole @ 29.0'			

RAILROAD RELOCATION

REMOLDED TESTING PROGRAM

	TYPE OF TEST	NO. OF TESTS
1.	Visual Classification	2
2.	Direct Shear	2
3.	$\bar{R}$ (rapid triaxial)	2
4.	Q (quick triaxial)	2
5.	Consolidation	2



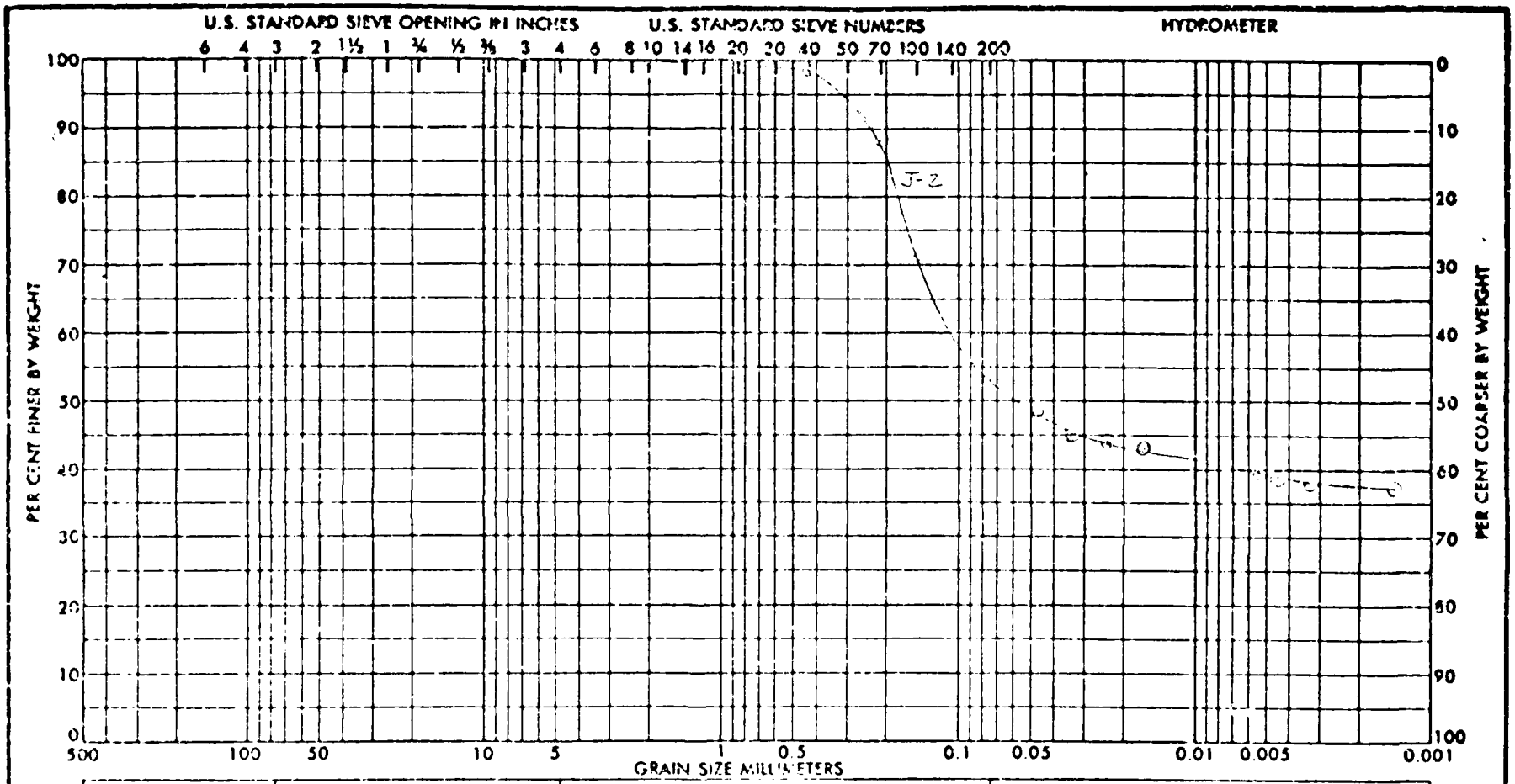
SAMPLE NO	ELEV OR DEPTH	CLASSIFICATION	NAT W%	LL	PL	PI
J-1	1.0'	medium to fine sandy clay (CL)		46	22	24

GRADATION CURVES

PROJECT Cooper River Rediversion
S. Charleston, S. Carolina
AREA Pinopolis Dikes
BORING NO J-1
DATE January 1976

ENG FORM 2087 (1 JAN 63) REPLACES WES FORM NO. 1241, SEP 1962, WHICH IS OBSOLETE

U.S. GOVERNMENT PRINTING OFFICE 1963 O—700-186



SAMPLE NO	ELEV OR DEPTH	CLASSIFICATION	NAT WC	LL	PL	PI
J-2	2.5'-3.0'	Lean Sandy Clay (CL)				

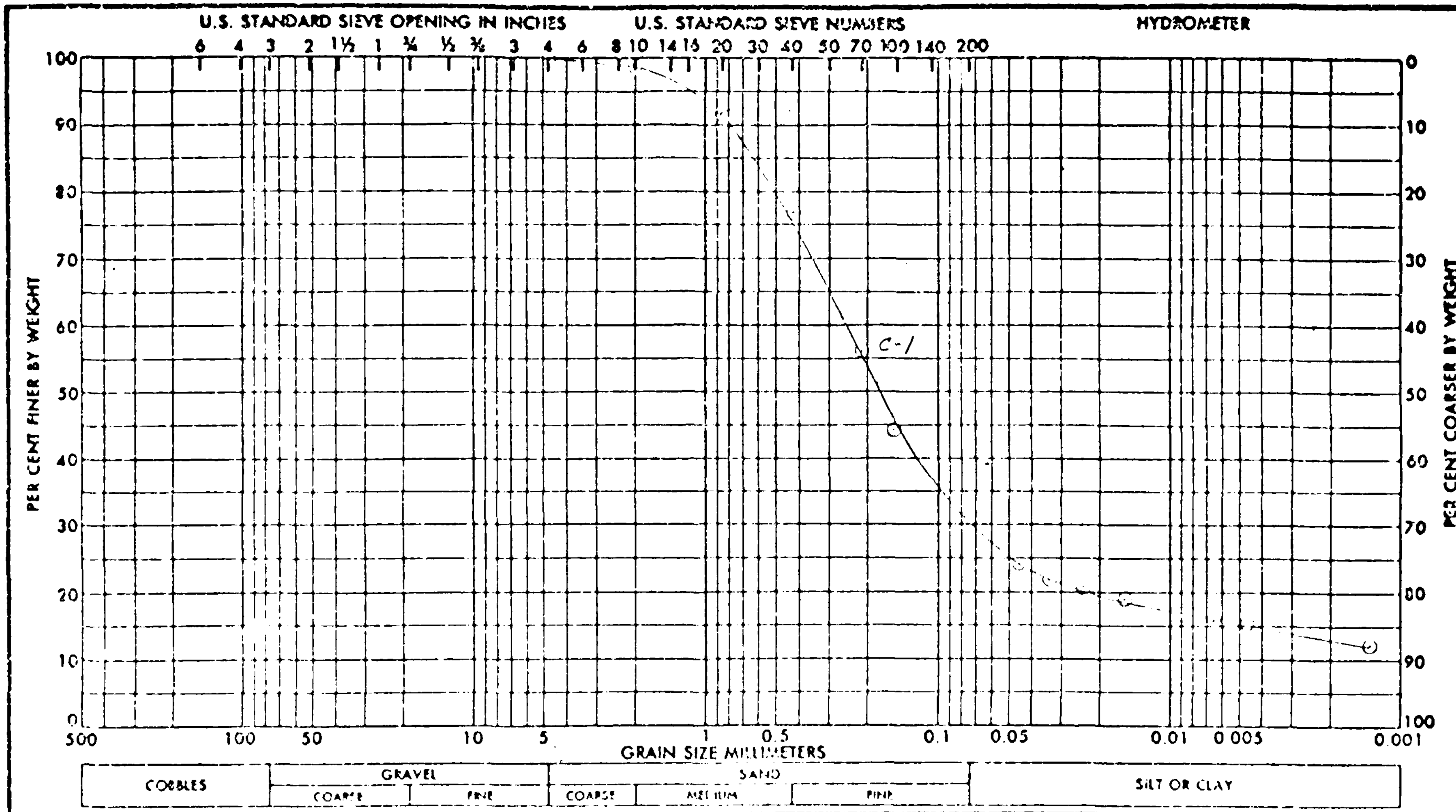
GRADATION CURVES

PROJECT Cooper River Realignment
St. Stephen, S. Carolina
AREA Railroad Relocation
BORING NO BAI-1
DATE January 1970

NO. 2087

REPLACES WES FORM NO. 1241, SEP 1963, WHICH IS OBSOLETE

U.S. GOVERNMENT PRINTING OFFICE



SAMPLE NO	ELEV OR DEPTH	CLASSIFICATION	NAT W%	LL	PL	PI
C-1	[illegible]	Clayey SAND (SC)		30	14	16

PROJECT Cooper River Rediversion St. Stephen, S. Carolina

AREA [illegible]

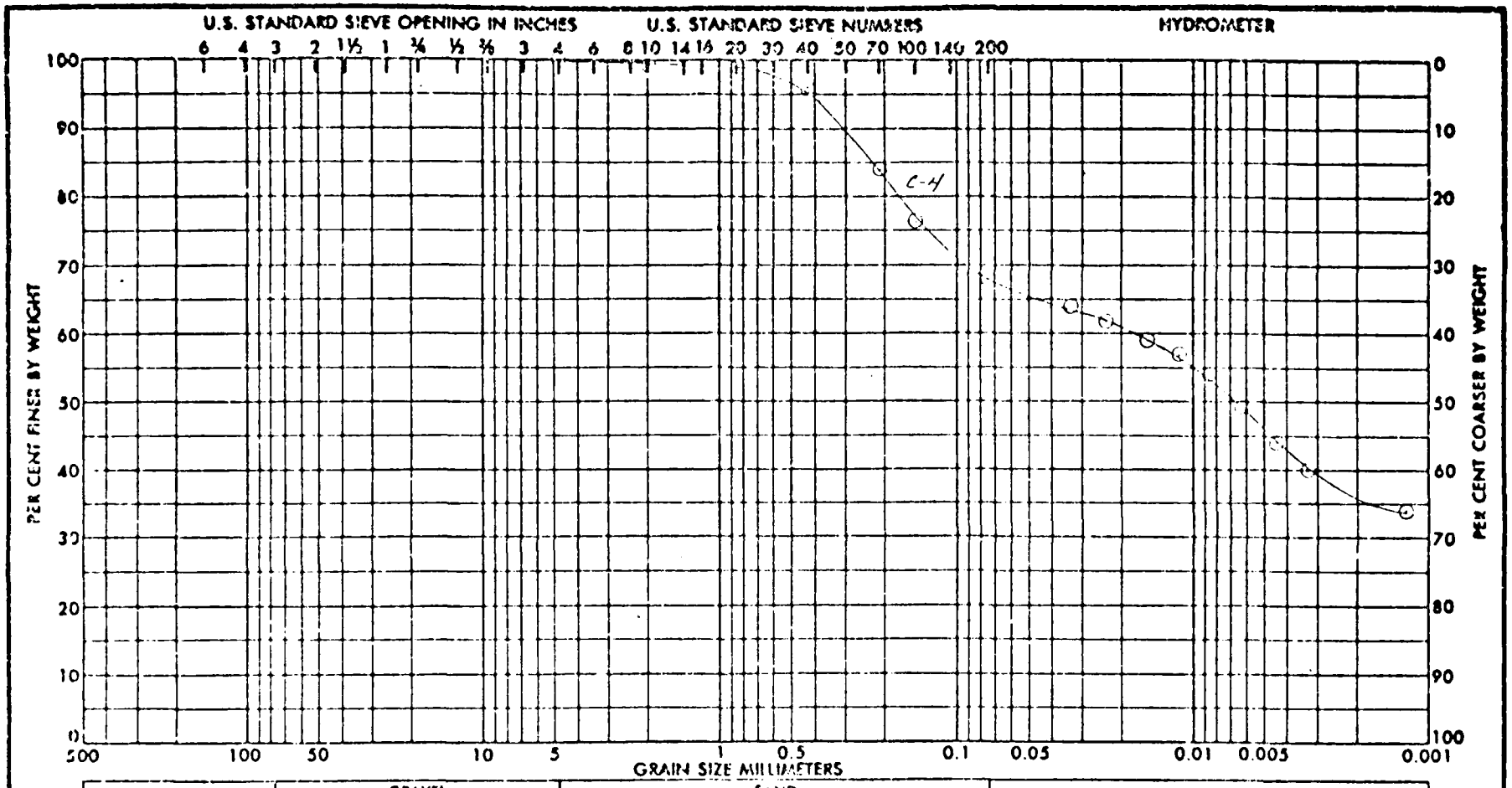
BORING NO [illegible]

DATE January 1976

GRADATION CURVES

ENG FORM 2087 REPLACES WES FORM NO. 1241, SEP 1952, WHICH IS OBSOLETE

U.S. GOVERNMENT PRINTING OFFICE



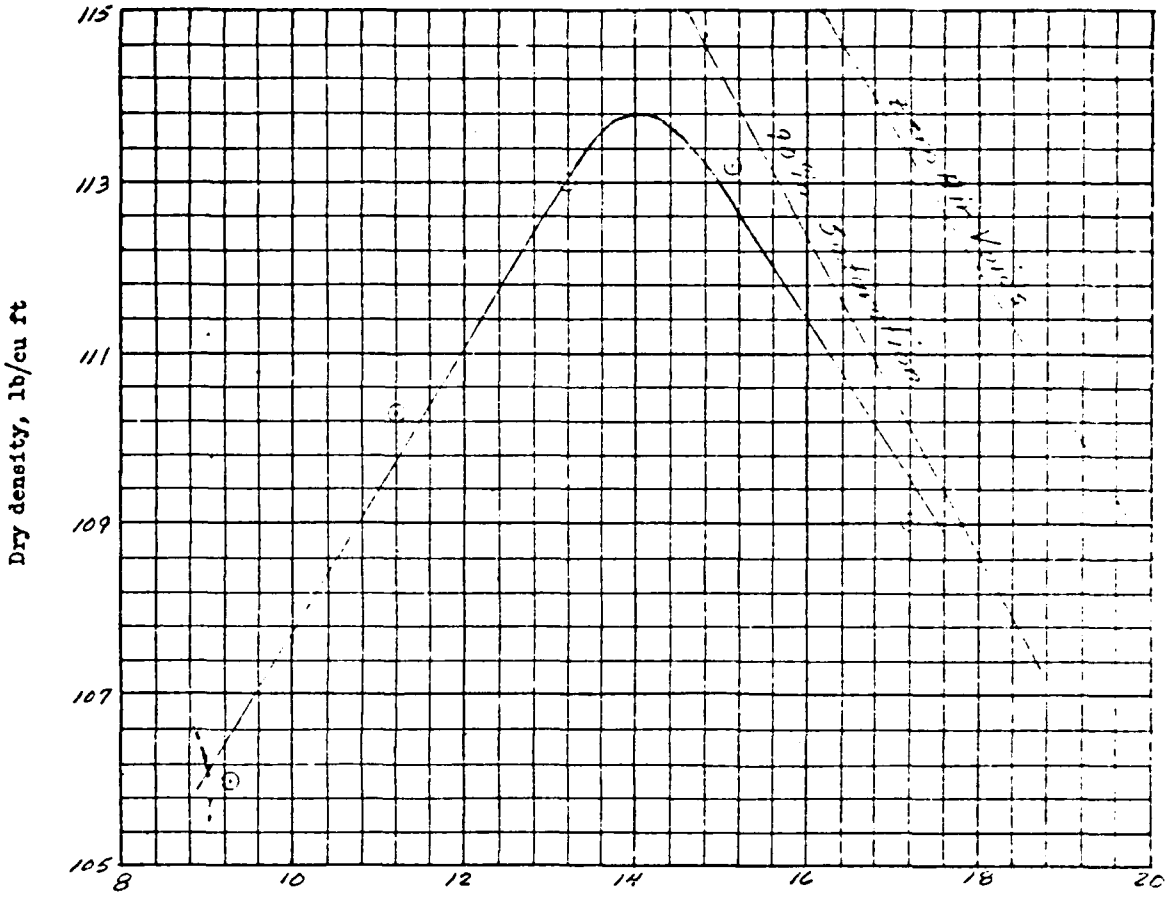
SAMPLE NO	ELEV OR DEPTH	CLASSIFICATION	NAT W%	LL	PI	PI
C-4	--	Fine sandy silty (CH)		64	26	38

GRADATION CURVES

PROJECT Cooper River Realignment
St. Stephens, S. Carolina
AREA Railroad Relocation
BORING NO C-4
DATE January 1976

ENG FORM 2087 REPLACES WES FORM NO. 1241, SEP 1962, WHICH IS OBSOLETE

U.S. GOVERNMENT PRINTING OFFICE 1965 O-795-150



Standard compaction test

25 blows per each of 3 layers, with 5.5 lb rammer and

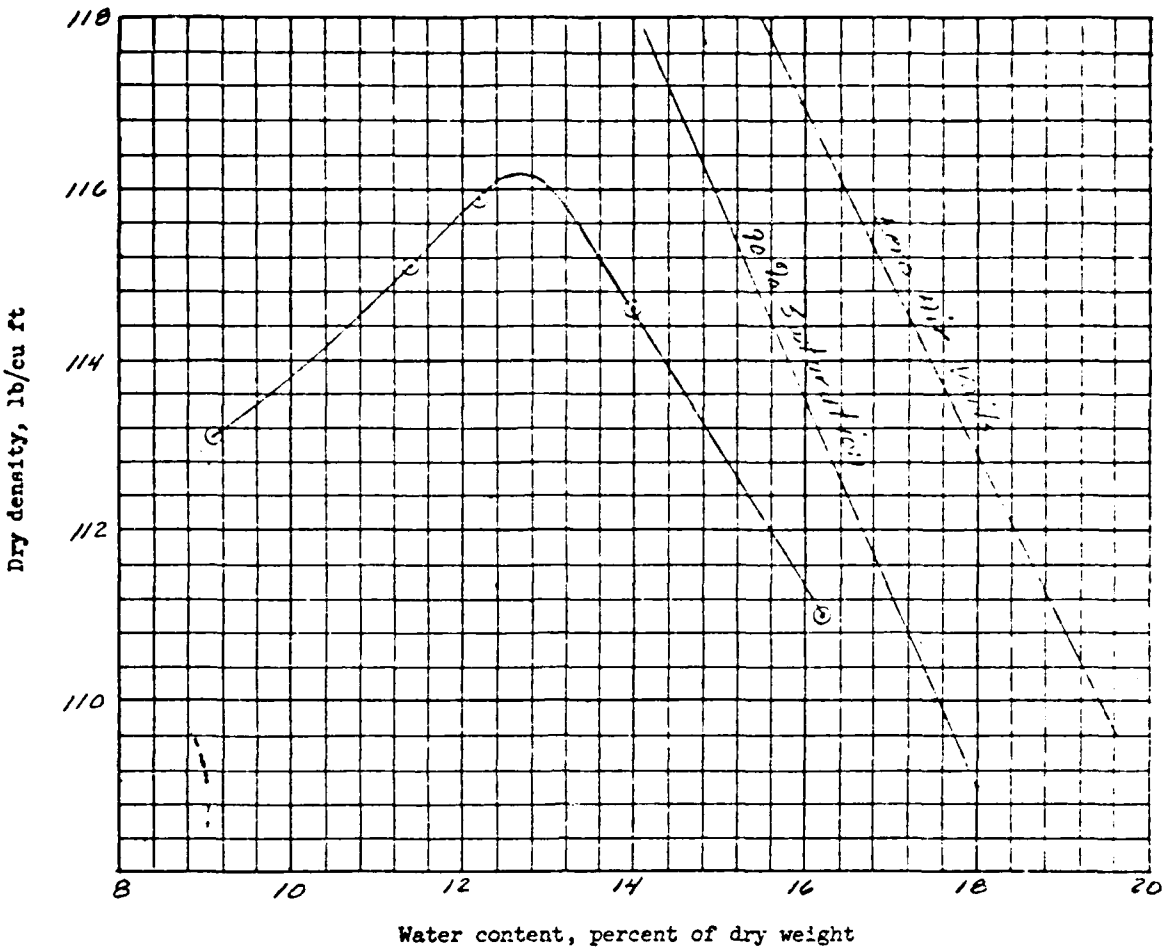
12 inch drop. 4.0 inch diameter mold

Sample No.	Elev or Depth	Classification	G	LL	PL	% > No. 4	% > 3/4 in.
C-1	1.5'-15'	Clayey SAND (SC)	2.66	30	14	0	0

Sample No.	C-1			
Natural water content, percent				
Optimum water content, percent	14.0			
Max dry density, lb/cu ft	113.8			

Remarks	Project Cooper River Restoration St. Stephen, S. Carolina
	Area Railroad Relocation
	Boring No. BH-1 / BH-2 Date January 1996
	COMPACTION TEST REPORT

ENG FORM 2091 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)



Standard compaction test

25 blows per each of 3 layers, with 5.5 lb rammer and

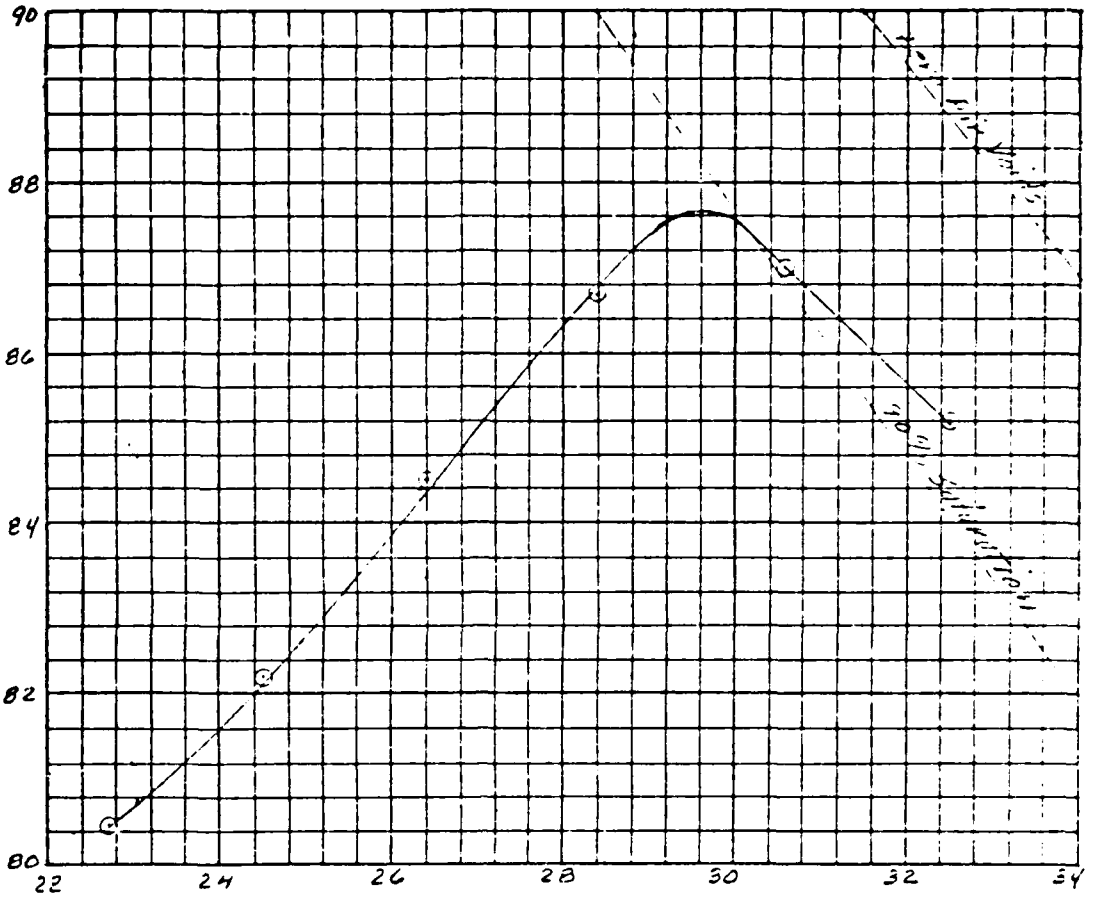
12 inch drop. 4 inch diameter mold

Sample No.	Elev or Depth	Classification	G	LL	PL	% > No. 4	% > 3/4 in.
C-2	3.0'-15.0'	clayey-silty fine SAND (SC-SM)	2.68	23	17	0	0

Sample No.	C-2			
Natural water content, percent				
Optimum water content, percent	12.6			
Max dry density, lb/cu ft	116.2			

Remarks	Project Cooper River Rediversion St. Stephens, S. Carolina
	Area Railroad Relocation
	Boring No. B-1 & B4-3 Date January 1972
	COMPACTION TEST REPORT

ENG FORM 1 JUN 65 2091 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)



Standard compaction test

25 blows per each of 3 layers, with 5.5 lb rammer and

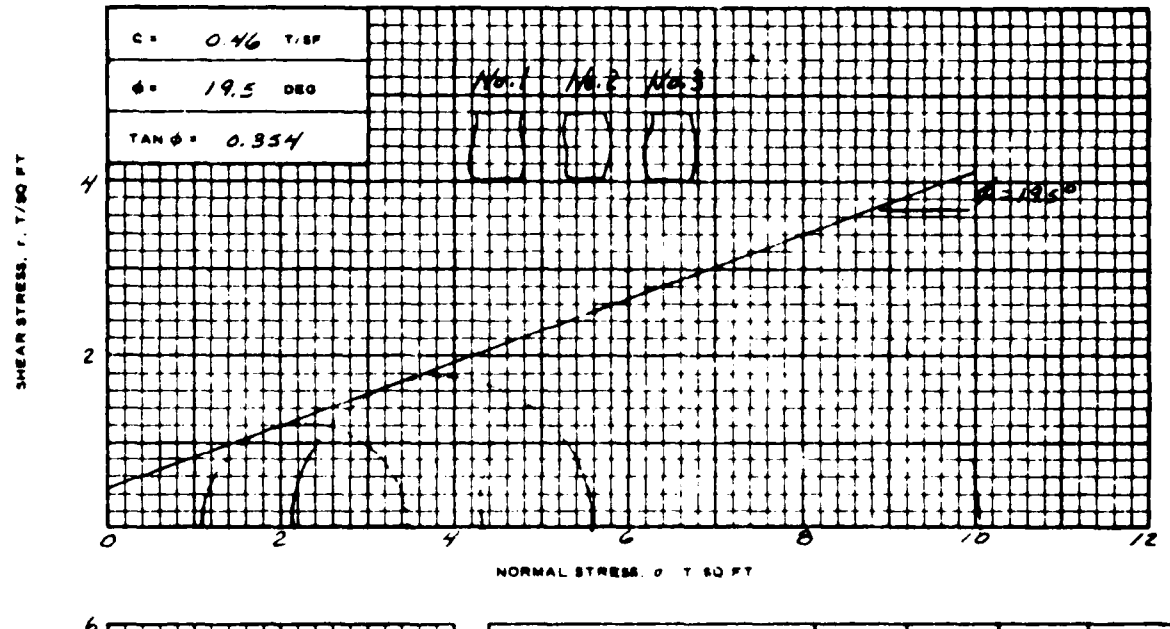
12 inch drop. 4 inch diameter mold

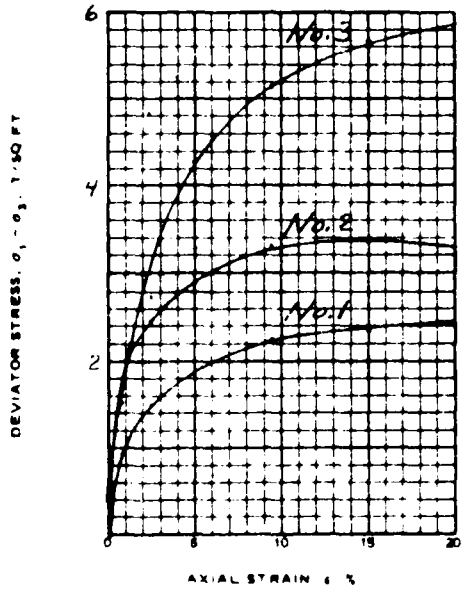
Sample No.	Elev or Depth	Classification	G	LL	PL	% > No. 4	% > 3/4 in.
C-4	-	Fine sandy CLAY (CH)	2.64	64	26	0	0

Sample No.	C-4			
Natural water content, percent				
Optimum water content, percent	29.6			
Max dry density, lb/cu ft	97.6			

Remarks	Project Cooper River Rediversion
	St. Stephen, S. Carolina
	Area Railroad Relocation
	Boring No. C-4 Date January 1976
	COMPACTION TEST REPORT

ENG FORM 1 JUN 65 2091 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)





SPECIMEN NO			1	2	3
INITIAL	WATER CONTENT %	w_o	16.5	16.2	17.0
	DRY DENSITY LB/CU FT	γ_{d_o}	107.8	108.5	107.7
	SATURATION, %	S_o	81.4	81.2	83.7
	VOID RATIO	e_o	0.539	0.530	0.541
BEFORE SHEAR	WATER CONTENT %	w_c			
	DRY DENSITY LB/CU FT	γ_{d_c}			
	SATURATION, %	S_c			
	VOID RATIO	e_c			
	FINAL BACK PRESSURE, T/SQ FT	u_b			
MINOR PRINCIPAL STRESS, T/SQ FT		σ_3	1.08	2.16	4.32
MAXIMUM DEVIATOR STRESS T SQ FT	$(\sigma_1 - \sigma_3)_{MAX}$		2.37*	3.77*	5.63
TIME TO $(\sigma_1 - \sigma_3)_{MAX}$ MIN		t_f	15	15	15
ULTIMATE DEVIATOR STRESS, T SQ FT	$(\sigma_1 - \sigma_3)_{ULT}$		—	—	—
INITIAL DIAMETER IN		D_c	1.42	1.42	1.42
INITIAL HEIGHT IN		H_o	3.15	3.15	3.15

CONTROLLED- strain TEST

DESCRIPTION OF SPECIMENS Clayey SAND (SC)

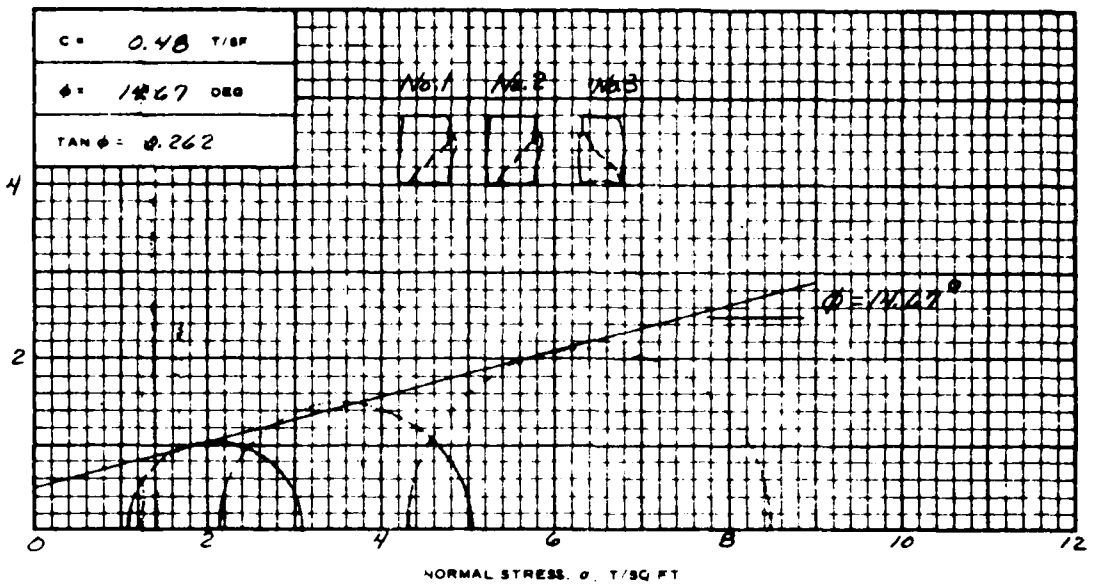
LL 30	PL 14	PI 16	Gs 2.66	TYPE OF SPECIMEN Remolded**	TYPE OF TEST Q

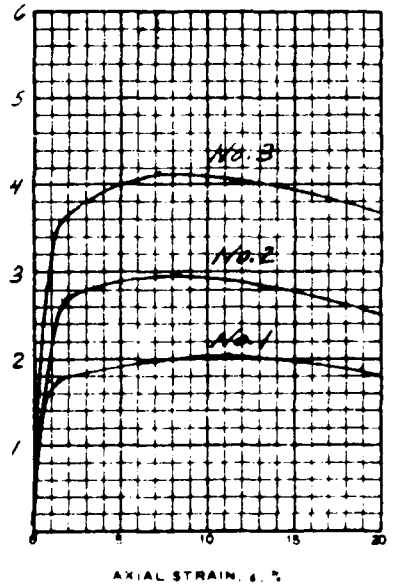
REMARKS *Stress @ 15% axial strain.
**Samples molded @ moisture content of 17.0% (O.M.C. + 3%) and dry density of 106.1 Pcf (95% maximum density)

PROJECT Cooper River Rediversion
St. Stephen, S. Carolina
BORING NO BA-1 & BA-2 SAMPLE NO C-1
DEPTH 1.5' - 15.0'
LABORATORY NED DATE March 1976

TRIAXIAL COMPRESSION TEST REPORT

ENG FORM NO 2089 REV JUNE 1970 PREVIOUS EDITION IS OBSOLETE TRANSLUCENT (EM 1110-2-1906)





SPECIMEN NO			1	2	3
INITIAL	WATER CONTENT %	w_o	17.0	17.0	17.0
	DRY DENSITY LB/CU FT	γ_{d_o}	108.1	108.1	108.1
	SATURATION %	S_o	84.4	84.4	84.4
	VOID RATIO	e_o	0.535	0.535	0.535
BEFORE SHEAR	WATER CONTENT, %	w_c	20.5	19.3	17.5
	DRY DENSITY LB/CU FT	γ_{d_c}	109.7	112.3	113.3
	SATURATION, %	S_c	100	100	100
	VOID RATIO	e_c	0.513	0.478	0.465
	FINAL BACK PRESSURE, T/SQ FT	u_o	7.20	7.20	7.20
MINOR PRINCIPAL STRESS, T SQ FT		σ_3	1.08	2.16	4.32
MAXIMUM DEVIATOR STRESS, T SQ FT		$(\sigma_1 - \sigma_3)_{MAX}$	2.02	2.94	4.16
TIME TO $(\sigma_1 - \sigma_3)_{MAX}$, MIN		t_f	65	41	41
ULTIMATE DEVIATOR STRESS, T SQ FT		$(\sigma_1 - \sigma_3)_{ult}$	1.91*	2.79*	3.97*
INITIAL DIAMETER, IN		D_o	1.42	1.42	1.42
INITIAL HEIGHT, IN		H_o	3.15	3.15	3.15

CONTROLLED TEST: strain

DESCRIPTION OF SPECIMENS: clayey SAND (SC)

LL	PL	PI	Gs
30	14	16	2.66

TYPE OF SPECIMEN: Remolded** | TYPE OF TEST: R

REMARKS: *stress @ 15% axial strain.
**Samples molded @ moisture content of 17.0% (o.m.c. ± 3%) and dry density of 108.1 Pcf (95% maximum density)

PROJECT: Cooper River Rediversion
St. Stephen, S. Carolina

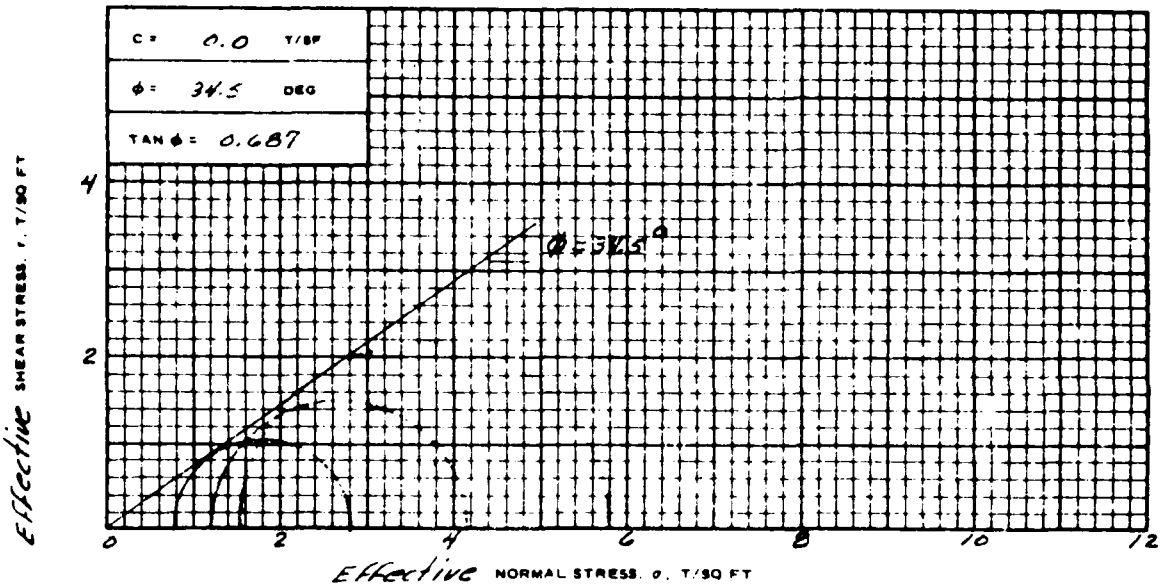
BORING NO: BA-1 & BA-2 | SAMPLE NO: C-1

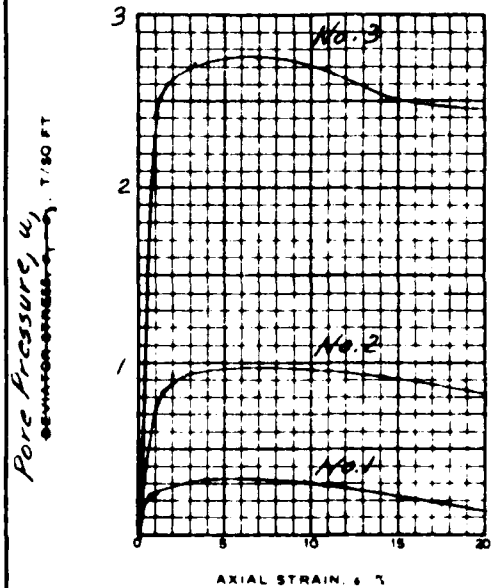
DEPTH: 1.5' - 15.0'

LABORATORY: NED | DATE: March 1976

TRIAXIAL COMPRESSION TEST REPORT

ENG FORM NO. 2089 REV JUNE 1970 PREVIOUS EDITION IS OBSOLETE TRANSLUCENT (EM 1110-2-1906)





SPECIMEN NO.			1	2	3
INITIAL	WATER CONTENT, %	w_o	17.0	17.0	17.0
	DRY DENSITY LB/CU FT	γ_{d_o}	108.1	108.1	108.1
	SATURATION, %	S_o	84.4	84.4	84.4
	VOID RATIO	e_o	0.535	0.535	0.535
BEFORE SHEAR	WATER CONTENT %	w_c	20.5	19.3	17.5
	DRY DENSITY LB/CU FT	γ_{d_c}	109.7	112.3	113.3
	SATURATION %	S_c	100	100	100
	VOID RATIO	e_c	0.513	0.478	0.465
	FINAL BACK PRESSURE, T/SQ FT	u_b	7.20	7.20	7.20
MINOR PRINCIPAL STRESS T/SQ FT		σ_3	0.79	1.20	1.57
MAXIMUM DEVIATOR STRESS T/SQ FT		$(\sigma_1-\sigma_3)_{MAX}$	2.02	2.94	4.16
TIME TO $(\sigma_1-\sigma_3)_{MAX}$, MIN		t_f	65	41	41
ULTIMATE DEVIATOR STRESS, T/SQ FT		$(\sigma_1-\sigma_3)_{ULT}$	1.96	2.79	3.97
~~FINAL DIAMETER IN~~ Major Prin. stress, T/SF		σ_1	2.81	4.14	5.73
~~FINAL HEIGHT IN~~ Pore Pressure, T/SF		u_f	+0.29*	+0.96*	+2.75*

CONTROLLED- strain TEST

DESCRIPTION OF SPECIMENS clayey SAND (SC)

LL 30 | PL 14 | PI 16 | Gs 2.66 | TYPE OF SPECIMEN Remolded | TYPE OF TEST R

REMARKS * Pore Pressure @ same % axial strain as Major and Minor Principal stresses.

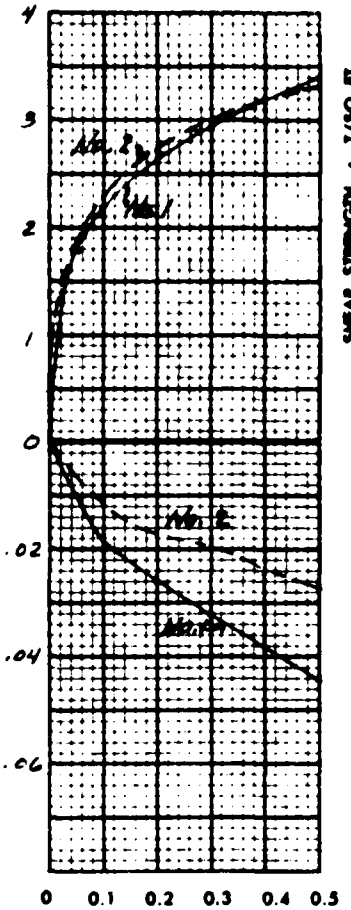
PROJECT Cooper River Rediversion
St. Stephen, S. Caroline

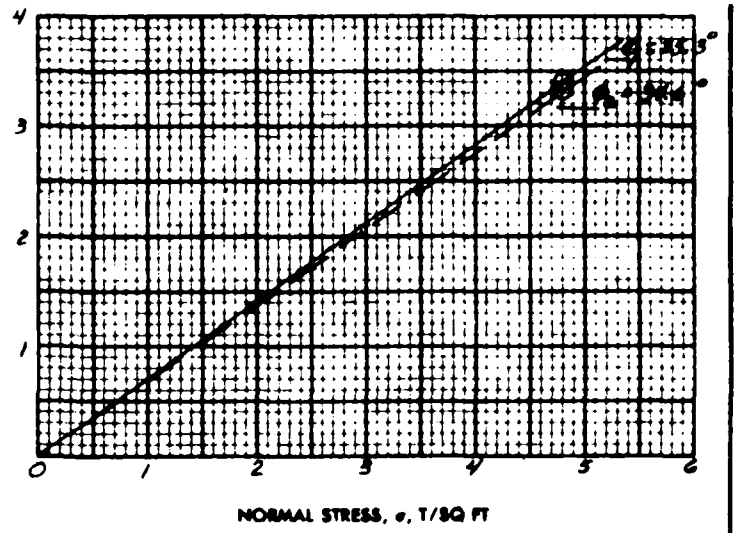
BORING NO BH-1 & BA-2 | SAMPLE NO C-1

DEPTH ~~ELEV~~ 1.5'-15.0'

LABORATORY NED | DATE March 1976

TRIAXIAL COMPRESSION TEST REPORT





TEST NO.			1	2		
INITIAL	WATER CONTENT	w_o	17.0 %	17.0 %	%	%
	VOID RATIO	e_o	0.536	0.536		
	SATURATION	S_o	84.4 %	84.4 %	%	%
	DRY DENSITY, LB/CU FT	γ_d	108.1	108.1		
VOID RATIO AFTER CONSOLIDATION		e_c	0.409	0.452		
TIME FOR 50 PERCENT CONSOLIDATION, MIN		t_{50}	0.5	0.5		
FINAL	WATER CONTENT	w_f	16.2 %	16.5 %	%	%
	VOID RATIO	e_f	0.274	0.375		
	SATURATION	S_f	100 %	100 %	%	%
NORMAL STRESS, T/SQ FT		σ	4.80	4.80		
MAXIMUM SHEAR STRESS, T/SQ FT		τ_{max}	3.40*	3.91*		
ACTUAL TIME TO FAILURE, MIN		t_f	60	60		
RATE OF STRAIN, IN./MIN			0.0083	0.0083		
ULTIMATE SHEAR STRESS, T/SQ FT		τ_{ult}	—	—		

SHEAR STRENGTH PARAMETERS

$\phi' =$ 34.6°

TAN $\phi' =$ 0.690

$c' =$ 0.0 T/SQ FT

☐ CONTROLLED STRESS

☒ CONTROLLED STRAIN

TYPE OF SPECIMEN Remolded** — 3.0 IN. SQUARE — 0.50 IN. THICK

CLASSIFICATION clayey SAND (SC)

LL 30 | PL 14 | PI 16 | | G_s 2.66

REMARKS *Stress @ 0.5" horizontal deformation

**Samples molded @ moisture content of 17.0% (O.M.C. +2%) and dry density of 100.1 PCF (95% maximum density)

PROJECT Cooper River Rediversion, St Stephen, S. Carolina

AREA Railroad Relocation

BORING NO. BA-1 & BA-2 | SAMPLE NO C-1

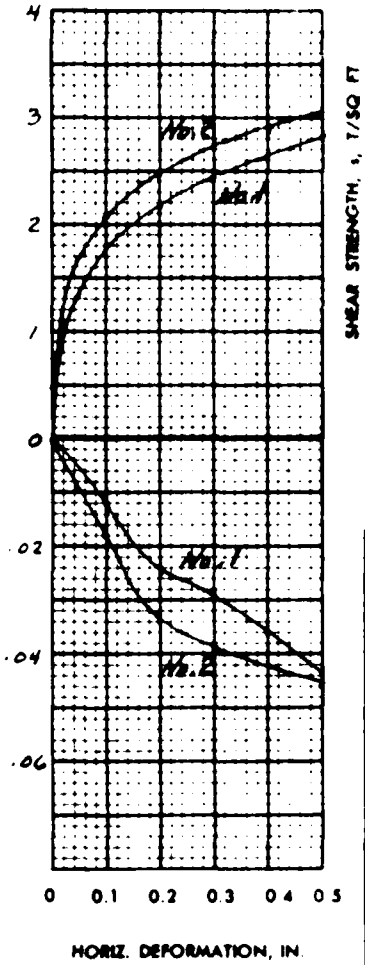
DEPTH 1.5'-15.0' | DATE March 1976

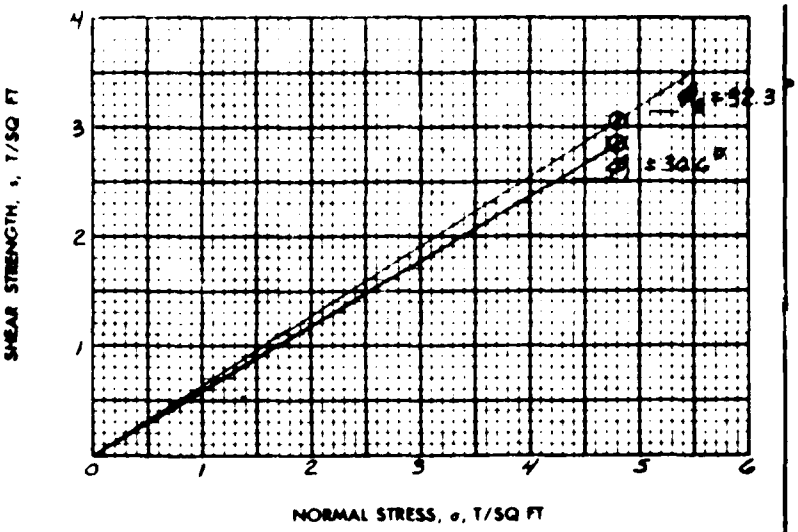
DIRECT SHEAR TEST REPORT

ENG FORM 2092 1 JUN 66 (EM 1110-2-1906) PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

GPO 1966 O-216-966

PLATE IX-3





TEST NO			1	2		
INITIAL	WATER CONTENT	w_o	14.0 %	14.0 %	%	%
	VOID RATIO	e_o	0.535	0.535		
	SATURATION	S_o	69.6 %	69.6 %	%	%
	DRY DENSITY, LB/CU FT	γ_d	108.1	108.1		
VOID RATIO AFTER CONSOLIDATION		e_f	0.450	0.487		
TIME FOR 50 PERCENT CONSOLIDATION, MIN		t_{50}	0.5	0.5		
FINAL	WATER CONTENT	w_f	16.6 %	16.5 %	%	%
	VOID RATIO	e_f	0.367	0.378		
	SATURATION	S_f	100 %	100 %	%	%
NORMAL STRESS, T/SQ FT		σ	4.80	4.80		
MAXIMUM SHEAR STRESS, T/SQ FT		τ_{max}	2.83 *	3.08 *		
ACTUAL TIME TO FAILURE, MIN		t_f	60	60		
RATE OF STRAIN, IN./MIN			0.0083	0.0083		
ULTIMATE SHEAR STRESS, T/SQ FT		τ_{ult}	—	—		

SHEAR STRENGTH PARAMETERS

ϕ' = 30.6

TAN ϕ = 0.590

c' = 0.0 T/SQ FT

☐ CONTROLLED STRESS

☒ CONTROLLED STRAIN

TYPE OF SPECIMEN Remolded ** 3.0 IN. SQUARE 0.50 IN. THICK

CLASSIFICATION clayey SAND (SC)

LL	PL	PI		G.
30	14	16		2.66

REMARKS * Stress @ 0.50" horizontal deformation.

** Samples molded @ approx. moisture content of 14.0% (O.M.) and dry density of 108.1 Pcf (95% maximum density)

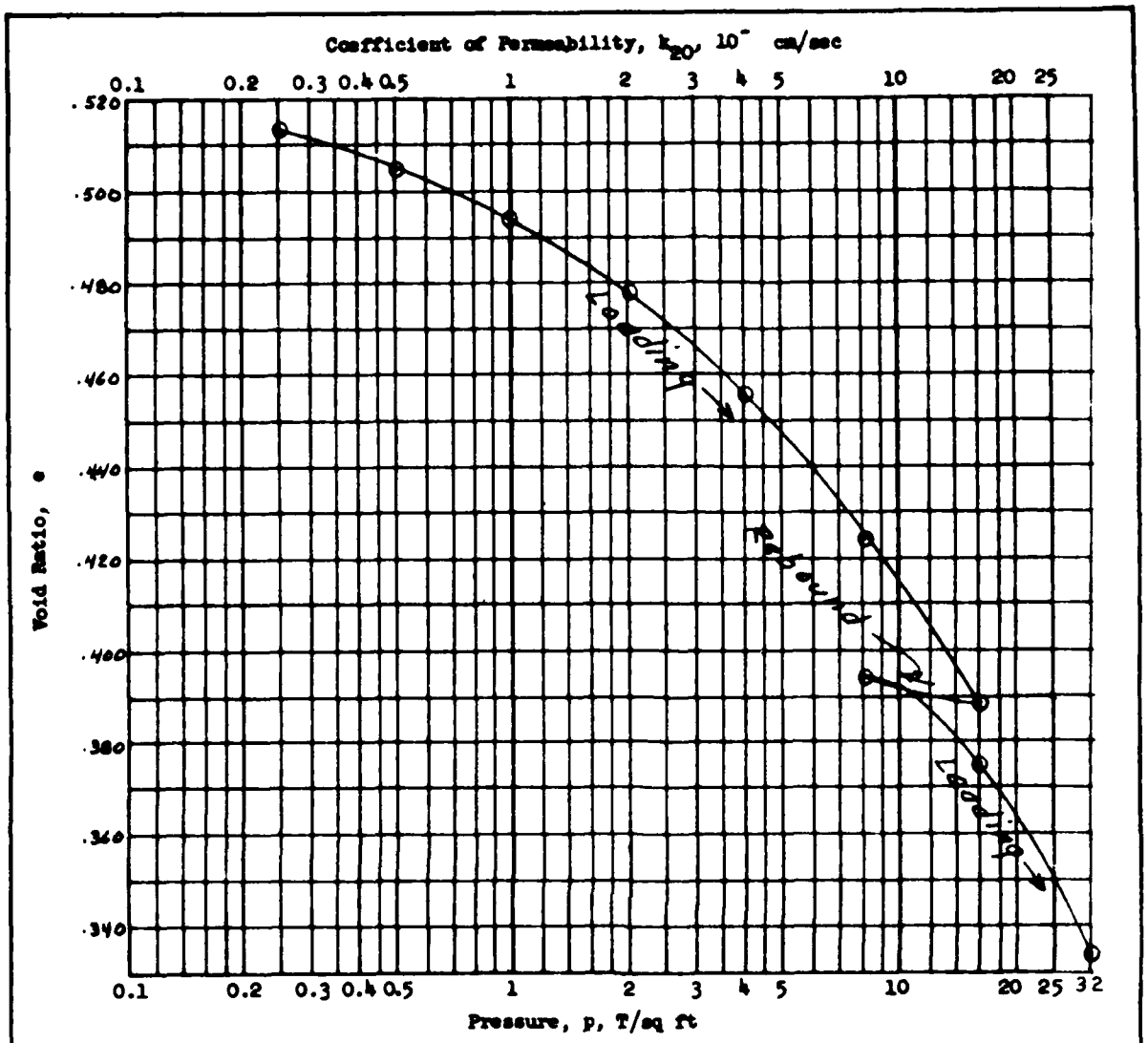
PROJECT Cooper River Rediversion
St. Stephen, S. Carolina

AREA Railroad Relocation

BORING NO BA-1 & BA-2 SAMPLE NO C-1

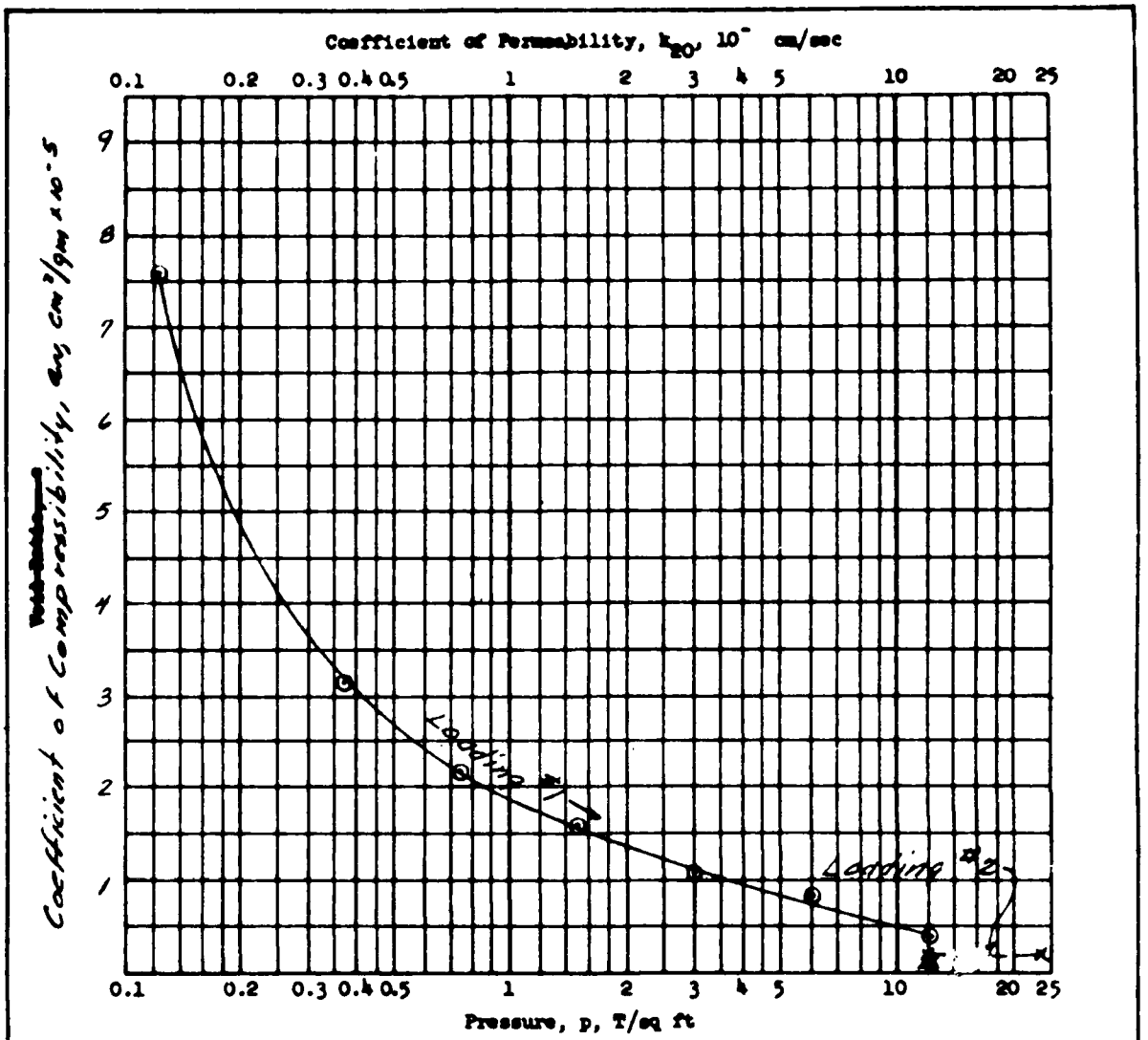
DEPTH * 1.5' - 15.0' DATE March 1976

DIRECT SHEAR TEST REPORT



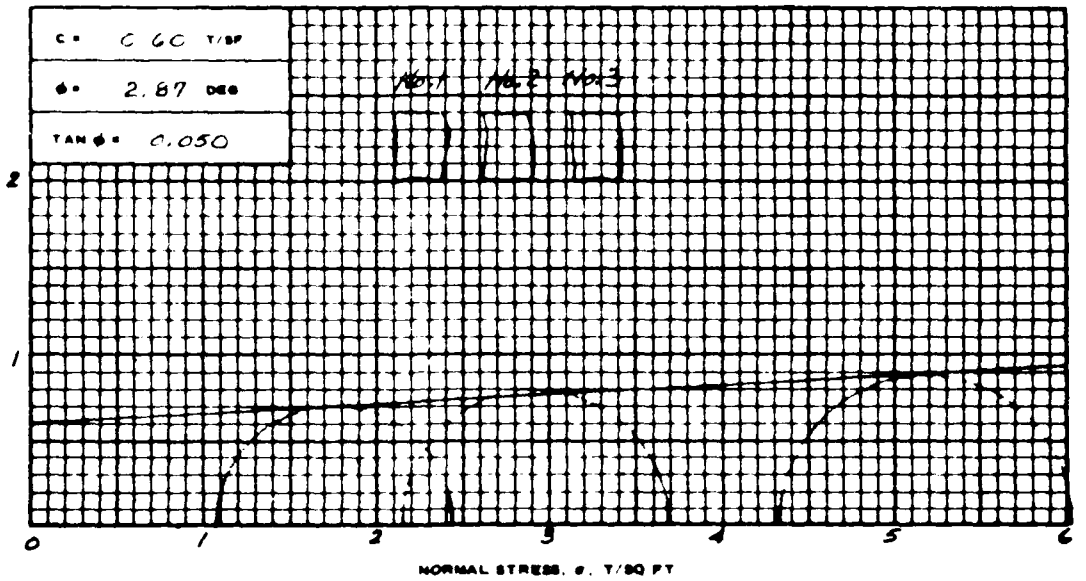
Type of Specimen *Remolded*		Before Test		After Test	
Diam *4.45* in.	Ht *1.0* in.	Water Content, w_o	*16.9* %	w_f	*12.6* %
Overburden Pressure, Po	T/sq ft	Void Ratio, e_o	*0.532*	e_f	*0.334*
Preconsol. Pressure, Pc	T/sq ft	Saturation, S_o	*84.4* %	S_f	*100* %
Compression Index, C_c *0.12*		Dry Density, γ_d	*108.4* lb/ft^3		
Classification *clayey SAND (SC)*		k_{20} at e_o =	x 10^{-} cm/sec		
LL *30*	G_s *2.66*	Project *Cooper River Rediversion*			
PL *14*	D_{10}	*St. Stephen, S. Carolina*			
Remarks *Samples molded @ moisture content of 12.0% (O.M.C. 12%) and dry density of 108.1 PCF (95% maximum density)*		Area *RAILROAD RELOCATION*			
		Boring No. *BA-1 & BA-2*		Sample No. *C-1*	
		Depth Ht *1.5' - 15.0'*		Date *March 1976*	
		CONSOLIDATION TEST REPORT			

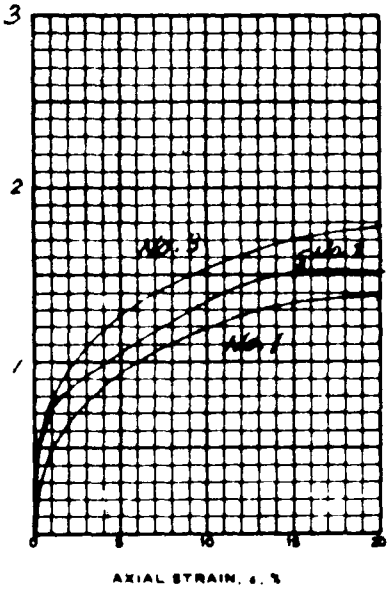
ENG FORM 1 MAY 68 2090 PREVIOUS EDITIONS ARE OBSOLETE.



Type of Specimen *Remolded*		Before Test		After Test	
Diam *4.45* in.	Ht *1.0* in.	Water Content, w_o	*16.9* %	w_f	*12.6* %
Overburden Pressure, p_o	T/sq ft	Void Ratio, e_o	*0.532*	e_f	*0.334*
Preconsol. Pressure, p_c	T/sq ft	Saturation, S_o	*84.4* %	S_f	*100* %
Compression Index, C_c *0.12*		Dry Density, γ_d	*108.4* lb/ft³		
Classification *clayey SAND (SC)*		k_{20} at e_o =	x 10^{-} cm/sec		
LL *30*	G_s *2.66*	Project *Cooper River Rediversion*			
PL *14*	D_{10}	*St. Stephen, S. Carolina*			
Remarks *Samples molded @ moisture content of 120% (o.m.c. 13%) and dry density of 108.1 pcf. (95% maximum density)*		Area *RAILROAD RELOCATION*			
		Boring No. *BA-1 & BA-2*	Sample No. *C-1*		
		Depth *1.5' - 15.0'*	Date *March 1976*		
		CONSOLIDATION TEST REPORT			

ENG FORM 2090 1 MAY 68 PREVIOUS EDITIONS ARE OBSOLETE.





SPECIMEN NO.			1	2	3
INITIAL	WATER CONTENT, %	w_o	33.4	32.3	32.1
	DRY DENSITY LB/CU FT	γ_{d_o}	83.1	82.9	83.1
	SATURATION, %	S_o	89.7	86.3	86.3
	VOID RATIO	e_o	0.983	0.987	0.981
BEFORE SHEAR	WATER CONTENT, %	w_c			
	DRY DENSITY LB/CU FT	γ_{d_c}			
	SATURATION, %	S_c			
	VOID RATIO	e_c			
	FINAL BACK PRESSURE, T/SQ FT	u_b			
MINOR PRINCIPAL STRESS, T/SQ FT		σ_3	1.08	2.16	4.82
MAXIMUM DEVIATOR STRESS, T/SQ FT	$(\sigma_1 - \sigma_3)_{MAX}$		1.35*	1.50*	1.71*
TIME TO $(\sigma_1 - \sigma_3)_{MAX}$, MIN		t_f	15	15	15
ULTIMATE DEVIATOR STRESS, T/SQ FT	$(\sigma_1 - \sigma_3)_{ULT}$		—	—	—
INITIAL DIAMETER, IN.		D_o	1.42	1.42	1.42
INITIAL HEIGHT, IN.		H_o	3.15	3.15	3.15

CONTROLLED- strain TEST

DESCRIPTION OF SPECIMENS fine sandy CLAY (CH) - Composite of R-1, R-2, R-3, R-4

LL 64 | PL 26 | PI 38 | Gs 2.64

TYPE OF SPECIMEN Remolded ** | TYPE OF TEST Q

REMARKS: *Stress @ 15% axial strain

**Samples molded @ approx. moisture content of 32.6% (o.m.c. +3%) and dry density of 83.2 pcf (95% maximum density)

PROJECT Cooper River Rediversion
St. Stephen, S. Carolina

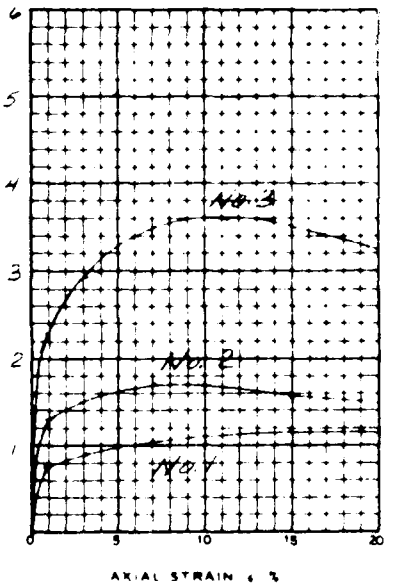
BORING NO. C-4 | SAMPLE NO. C-4

DEPTH/ELEV —

LABORATORY NED | DATE March 1976

TRIAXIAL COMPRESSION TEST REPORT

ENG FORM NO. 2089 REV JUNE 1970 PREVIOUS EDITION IS OBSOLETE TRANSLUCENT (EM 1110-2-1906)



TYPE SPECIMEN NO			2	3
AFTER	WATER CONTENT %	w_0	31.3	33.6
	DRY DENSITY LB/CU FT	γ_{d_0}	82.1	83.2
	SATURATION %	S_0	84.6	84.4
	VOID RATIO	e_0	1.004	1.035
BEFORE SHEAR	WATER CONTENT %	w_c	33.5	33.2
	DRY DENSITY LB/CU FT	γ_{d_c}	82.4	83.2
	SATURATION %	S_c	100	100
	VOID RATIO	e_c	1.004	1.000
	FINAL BACK PRESSURE T SQ FT	u_0	1.20	1.20
MINOR PRINCIPAL STRESS T SQ FT		σ_3	1.09	2.16
MAXIMUM DEVIATOR STRESS T SQ FT	$(\sigma_1 - \sigma_3)_{MAX}$		1.18*	1.70
TIME TO $(\sigma_1 - \sigma_3)_{MAX}$ MIN		t_f	90	41
ULTIMATE DEVIATOR STRESS, T SQ FT	$(\sigma_1 - \sigma_3)_{ULT}$		---	1.54*
INITIAL DIAMETER IN		D_0	1.42	1.42
INITIAL HEIGHT, IN		H_0	3.15	3.15

CONTROLLED STRAIN TEST

DESCRIPTION OF SPECIMENS Fine sandy CLAY (CH)

LL 64	PL 26	PI 38	Gs 2.64

REMARKS *Stress @ 15% axial strain

**Samples yielded @ approx. moisture content of 32.6% (O.M.C. +3%) and dry density of 83.2 pcf (95% maximum density)

TYPE OF SPECIMEN Remolded TYPE OF TEST CU

PROJECT Cooper River Replacement
St Stephen, S. Carolina

BORING NO C-4 SAMPLE NO 1-4

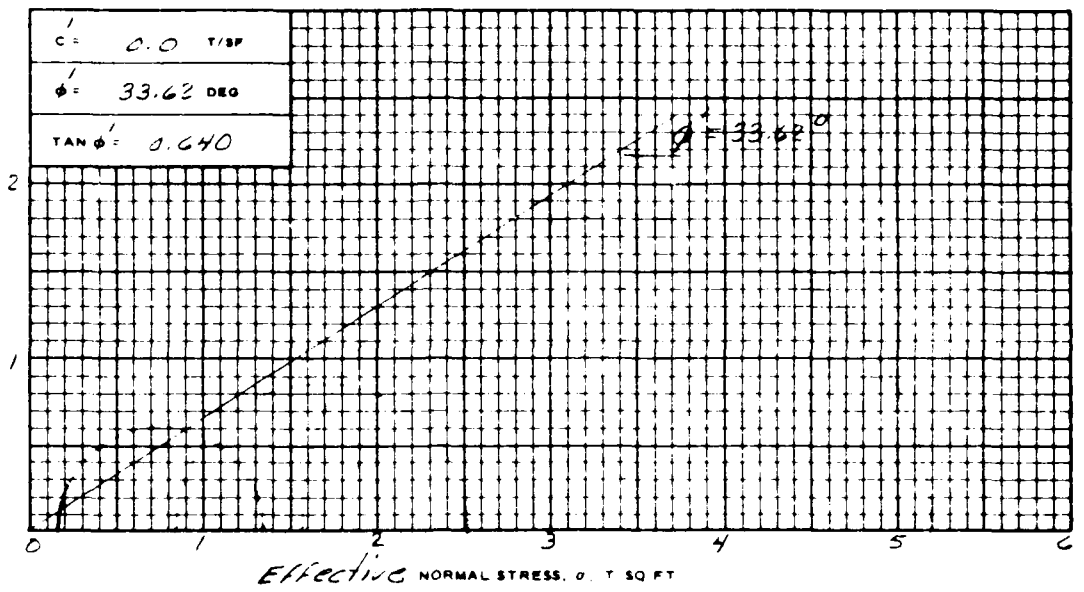
DEPTH ELEV --

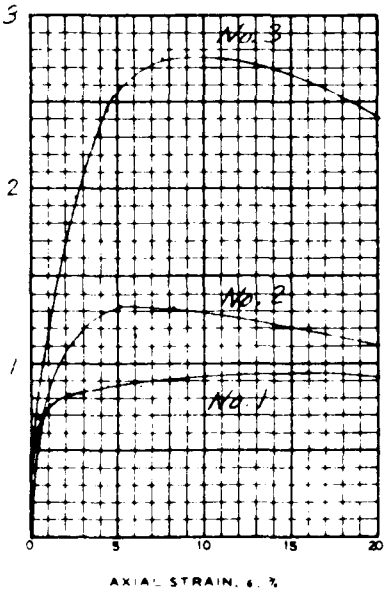
LABORATORY NED DATE 11-[illegible]-76

TRIAXIAL COMPRESSION TEST REPORT

ENG FORM NO 2089 REV JUNE 1970 PREVIOUS EDITION IS OBSOLETE TRANSLUCENT (EM 1110-2-1906)

C' =	0.0 T/SF
ϕ' =	33.62 DEG
TAN ϕ' =	0.640





SPECIMEN NO.			1	2	3
INITIAL	WATER CONTENT, %	w_o	32.2	32.4	33.0
	DRY DENSITY LB/CU FT	γd_o	83.2	82.0	83.0
	SATURATION, %	S_o	87.4	84.0	88.4
	VOID RATIO	e_o	0.974	1.004	0.985
BEFORE SHEAR	WATER CONTENT, %	w_c	34.5	33.5	31.3
	DRY DENSITY LB/CU FT	γd_c	86.2	87.4	90.2
	SATURATION, %	S_c	100	100	100
	VOID RATIO	e_c	0.9[illegible]	0.954	0.8[illegible]
	FINAL BACK PRESSURE, T/SQ FT	u_o	7.20	7.20	7.20
MINOR PRINCIPAL STRESS, T SQ FT		σ_3	0.16	0.34	1.[illegible]
MAXIMUM DEVIATOR STRESS, T SQ FT		$(\sigma_1-\sigma_3)_{MAX}$	1.18	1.70	3.62
TIME TO $(\sigma_1-\sigma_3)_{MAX}$, MIN		t_f	90	41	0.5
ULTIMATE DEVIATOR STRESS, T SQ FT		$(\sigma_1-\sigma_3)_{ULT}$	–	1.54	3.49
~~INITIAL DIAMETER, IN~~ Major Prin. Stress, Tsf		σ_1	1.34	2.54	5.[illegible]7
~~INITIAL HEIGHT, IN~~ Pore Pressure, Tsf		u_f	+0.92*	+1.35*	+2.15*

CONTROLLED- STRAIN TEST

DESCRIPTION OF SPECIMENS Fine Sandy Clay (CH)

LL 64	PL 26	PI 38	Gs 2.64

TYPE OF SPECIMEN Remolded TYPE OF TEST R

REMARKS *Pore Pressure @ same % axial strain as Major and Minor Principal stresses

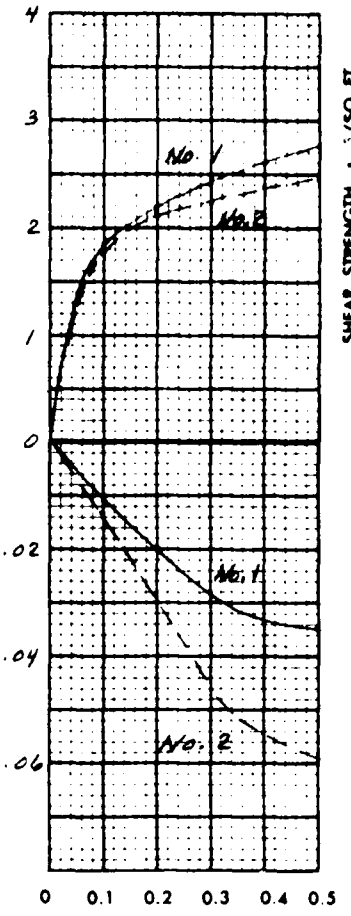
PROJECT Upper Kilauea Reservoir
St. Stephen, St. Croix

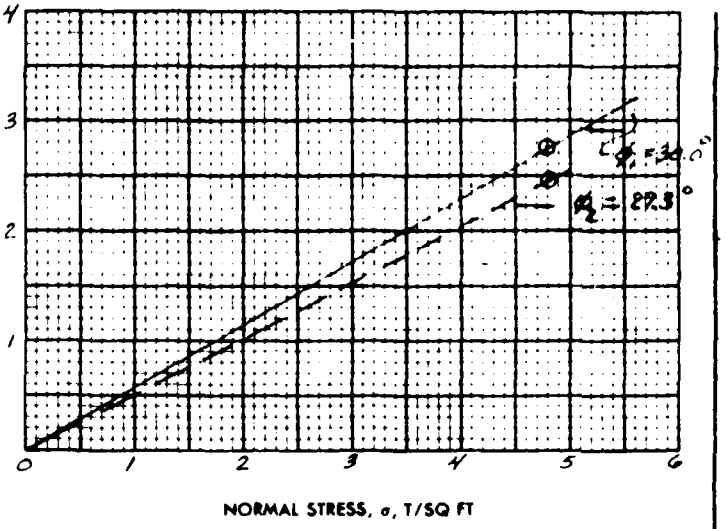
BORING NO C-4 SAMPLE NO C-4

DEPTH ELEV –

LABORATORY NEL DATE [illegible]76

TRIAXIAL COMPRESSION TEST REPORT





SHEAR STRENGTH PARAMETERS

ϕ = 27.3°

TAN ϕ = 0.510

c = 0.0 T/SQ FT

☐ CONTROLLED STRESS

☒ CONTROLLED STRAIN

TEST NO.			1	2		
INITIAL	WATER CONTENT	w_o	32.6 %	32.6%	%	%
	VOID RATIO	e_o	0.981	1.012		
	SATURATION	S_o	87.8 %	85.1%	%	%
	DRY DENSITY, LB/CU FT	γ_d	83.2	81.9		
VOID RATIO AFTER CONSOLIDATION		e_c	0.614	0.633		
TIME FOR 50 PERCENT CONSOLIDATION, MIN		t_{50}	0.60	0.60		
FINAL	WATER CONTENT	w_f	30.2 %	28.9 %	%	%
	VOID RATIO	e_f	0.480	0.399		
	SATURATION	S_f	100 %	100 %	%	%
NORMAL STRESS, T/SQ FT		σ	4.80	4.80		
MAXIMUM SHEAR STRESS, T/SQ FT		τ_{max}	2.77*	2.45*		
ACTUAL TIME TO FAILURE, MIN		t_f	60	60		
RATE OF STRAIN, IN /MIN			0.0083	0.0083		
ULTIMATE SHEAR STRESS, T/SQ FT		τ_{ult}	—			

TYPE OF SPECIMEN Remolded** — 3.0 IN. SQUARE — 0.50 IN. THICK

CLASSIFICATION Fine sandy CLAY (CH)

LL 64 | PL 26 | PI 38 | | G$_s$ 2.64

REMARKS * Stress @ 0.5" horizontal deformation

** Samples molded @ approx. moisture content of 32 (O.M.C.+ 3%) and dry density of 83.2 Pcf. (95% maximum density)

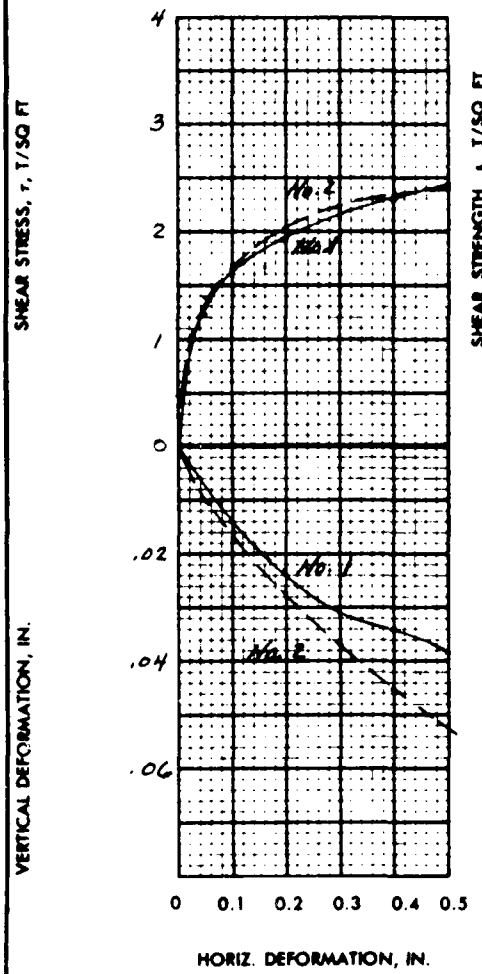
PROJECT Cooper River Rediversion
St. Stephen, S. Carolina

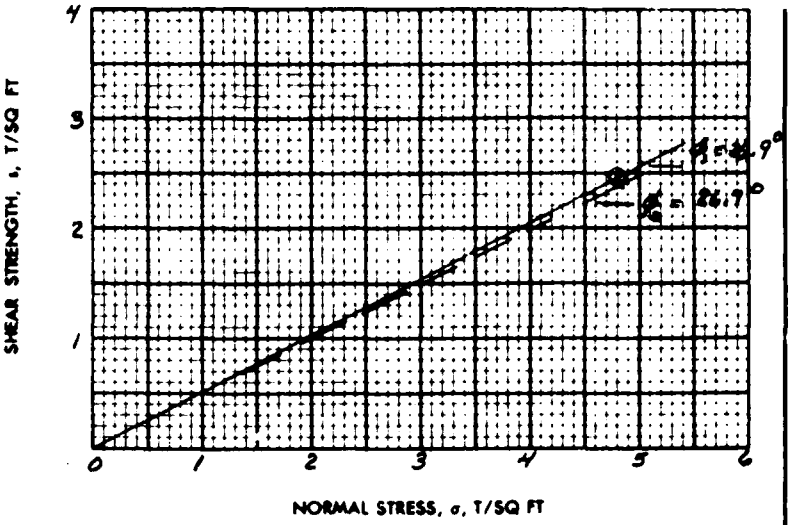
AREA Railroad Relocation

BORING NO C-4 | SAMPLE NO C-4

DEPTH EL – | DATE March 1976

DIRECT SHEAR TEST REPORT





TEST NO.			1	2		
INITIAL	WATER CONTENT	w_o	29.6 %	29.6 %	%	%
	VOID RATIO	e_o	0.980	0.980		
	SATURATION	S_o	79.7 %	79.7 %	%	%
	DRY DENSITY, LB/CU FT	γ_d	83.2	83.2		
VOID RATIO AFTER CONSOLIDATION		e_c	0.921	0.918		
TIME FOR 50 PERCENT CONSOLIDATION, MIN		t_{50}	0.60	0.60		
FINAL	WATER CONTENT	w_f	29.9 %	29.8 %	%	%
	VOID RATIO	e_f	0.726	0.715		
	SATURATION	S_f	100 %	100 %	%	%
NORMAL STRESS, T/SQ FT		σ	4.80	4.80		
MAXIMUM SHEAR STRESS, T/SQ FT		τ_{max}	2.43*	2.41*		
ACTUAL TIME TO FAILURE, MIN		t_f	60	60		
RATE OF STRAIN, IN./MIN			0.0083	0.0083		
ULTIMATE SHEAR STRESS, T/SQ FT		τ_{ult}	—	—		

SHEAR STRENGTH PARAMETERS

ϕ' = 26.7°

TAN ϕ' = 0.502

c' = 0 T/SQ FT

☐ CONTROLLED STRESS

☒ CONTROLLED STRAIN

TYPE OF SPECIMEN Remolded** IN. SQUARE IN. THICK

CLASSIFICATION Fine sandy CLAY (CH)

LL 64 PL 26 PI 38 G_s 2.64

REMARKS *Stress @ 0.5" horizontal deformation.

**Samples molded @ approx. moisture content of 29.6% (o.m.c.) and dry density of 83.2 Pcf, (95% maximum density)

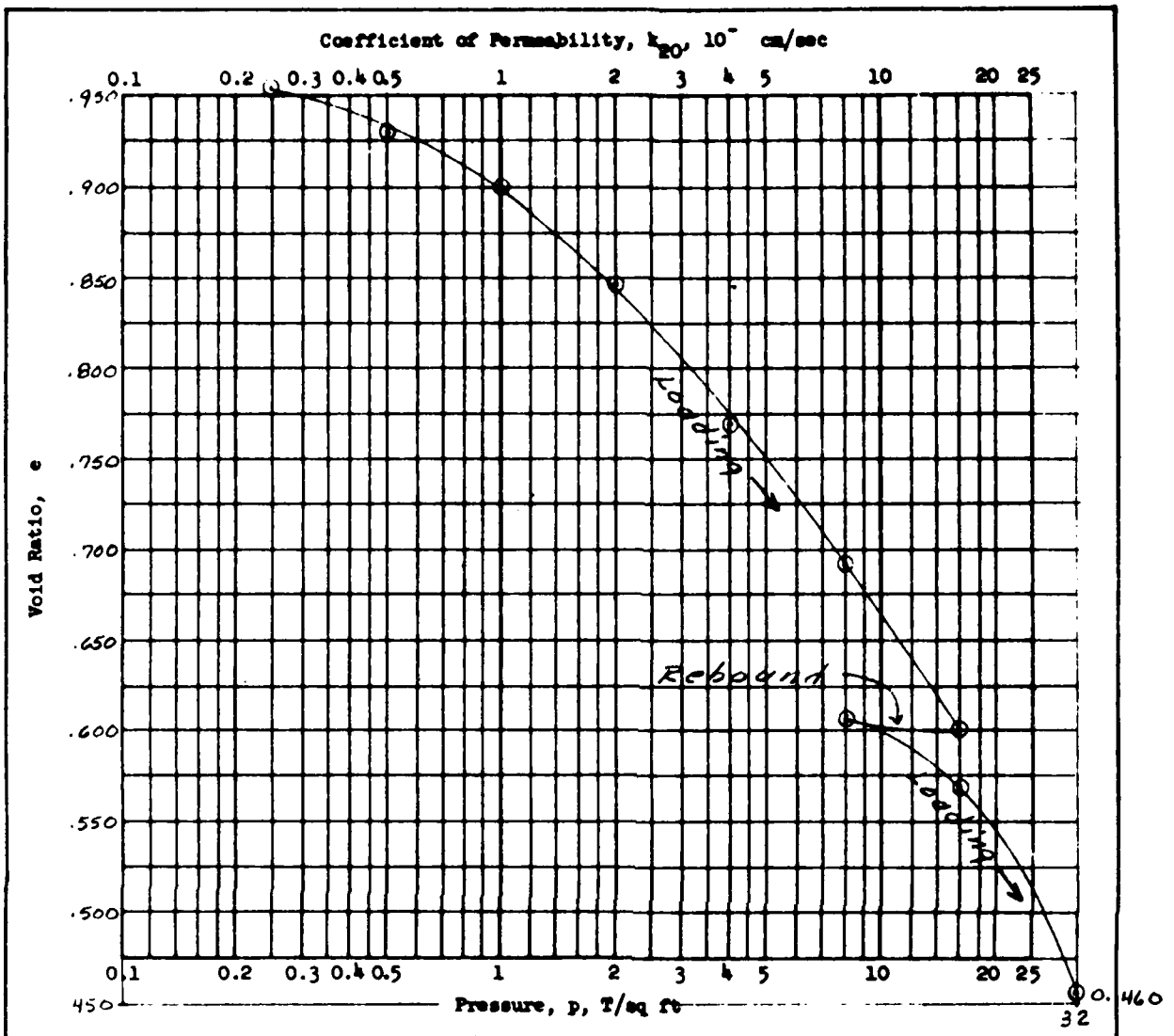
PROJECT Cooper River Rediversion
St. Stephen, S. Carolina

AREA Railroad Relocation

BORING NO. C-4 SAMPLE NO C-4

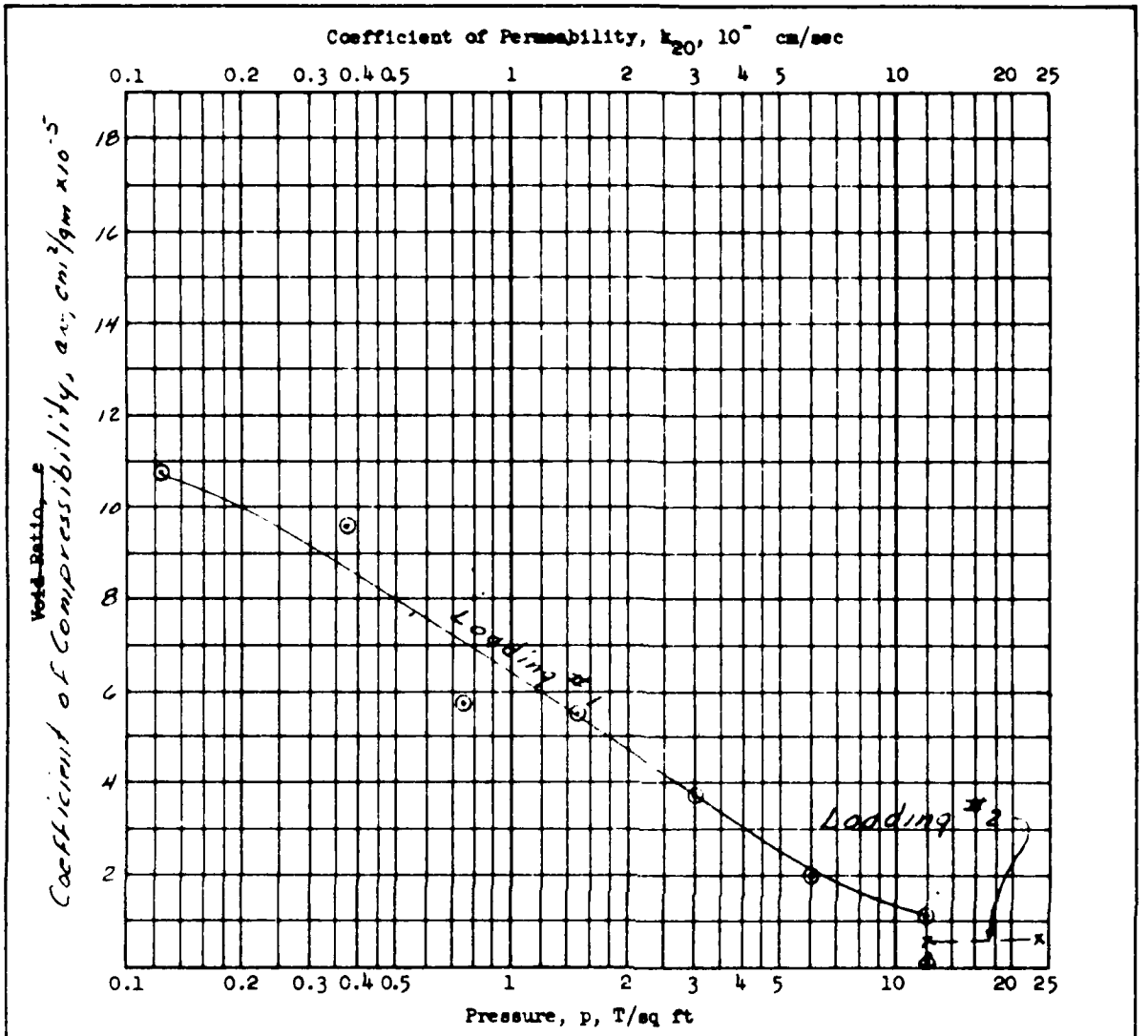
DEPTH — DATE March 1976

DIRECT SHEAR TEST REPORT



Type of Specimen *Remolded*		Before Test		After Test	
Diam *4.45* in.	Ht *1.0* in.	Water Content, w_o	*32.6* %	w_f	*30.6* %
Overburden Pressure, p_o	T/sq ft	Void Ratio, e_o	*0.980*	e_f	*0.460*
Preconsol. Pressure, p_c	T/sq ft	Saturation, S_o	*87.9* %	S_f	*100* %
Compression Index, C_c *0.29*		Dry Density, γ_d	*83.2* lb/ft^3		
Classification *fine sandy CLAY(CH)*		k_{20} at e_o =	x 10^{-} cm/sec		
LL *64*	G_s *2.64*	Project *Cooper River Rediversion*			
PL *26*	D_{10}	*St. Stephen, S. Carolina*			
Remarks *Samples molded @ approx. moisture content of 32.6% (o.m.c.+3%) and dry density of 83.2 Pcf (95% maximum density)*		Area *RAILROAD RELOCATION*			
		Boring No. *C-4*	Sample No. *C-4*		
		Depth El –	Date *March 1976*		
		CONSOLIDATION TEST REPORT			

ENG FORM 1 MAY 63 2090 PREVIOUS EDITIONS ARE OBSOLETE.



Type of Specimen *Remolded*		Before Test		After Test	
Diam 4.45 in.	Ht 1.0 in.	Water Content, w_o	%	w_f	%
Overburden Pressure, p_o	T/sq ft	Void Ratio, e_o		e_f	
Preconsol. Pressure, p_c	T/sq ft	Saturation, S_o	%	S_f	%
Compression Index, C_c 0.29		Dry Density, γ_d	lb/ft^3		
Classification *fine sandy CLAY (CH)*		k_{20} at e_o =	$\times 10^{-}$ cm/sec		
LL 64	G_s 2.64	Project *Cooper River Rediversion*			
PL 26	D_{10}	*St. Stephen, S. Carolina*			
Remarks *Sample molded @ approx.*		Area *PHILRCND RELOCATION*			
moisture content of 32.6%		Boring No. *C-4*	Sample No. *C-4*		
(O.M.C. + 3%) and dry density		Depth El –	Date *March 1976*		
of 63.2 Pcf (95% maximum density)		**CONSOLIDATION TEST REPORT**			

ENG FORM 2090 1 MAY 65 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

3424

END

FILMED

4-85

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